

FISH, REGIME SHIFTS, & THE FUTURE OF SUISUN MARSH

Peter Moyle

NOVEMBER 2009

GOALS OF TALK

- NATURE OF SUISUN MARSH TODAY
- WHAT HAVE WE LEARNED FROM 30 YRS OF STUDYING FISH & INVERTS?
- WHAT IS THE FUTURE OF SSM AS AN ECOSYSTEM?
- CAN WE AFFECT THE FUTURE OF SSM?

Suisun Marsh:

diked freshwater marsh with tidal brackish channels

470
km²

370
km
levees





SUISUN MARSH IS ON THE URBAN FRINGE

158 private duck clubs and 5 public wildlife/open space areas

Channels and marshlands treated as independent entities

A wide-angle photograph of a coastal wetland area. In the foreground, there are several rectangular agricultural fields, some with green crops and others brown and fallow. Beyond the fields, a complex network of narrow, winding water channels cuts through a landscape of green and brown marshland. In the background, a range of hills or low mountains is visible under a clear blue sky.

Pond food web

Tule root food web

Pelagic food web

Terrestrial food webs



Marsh

Pond

Channels and diked marsh are connected, even now.

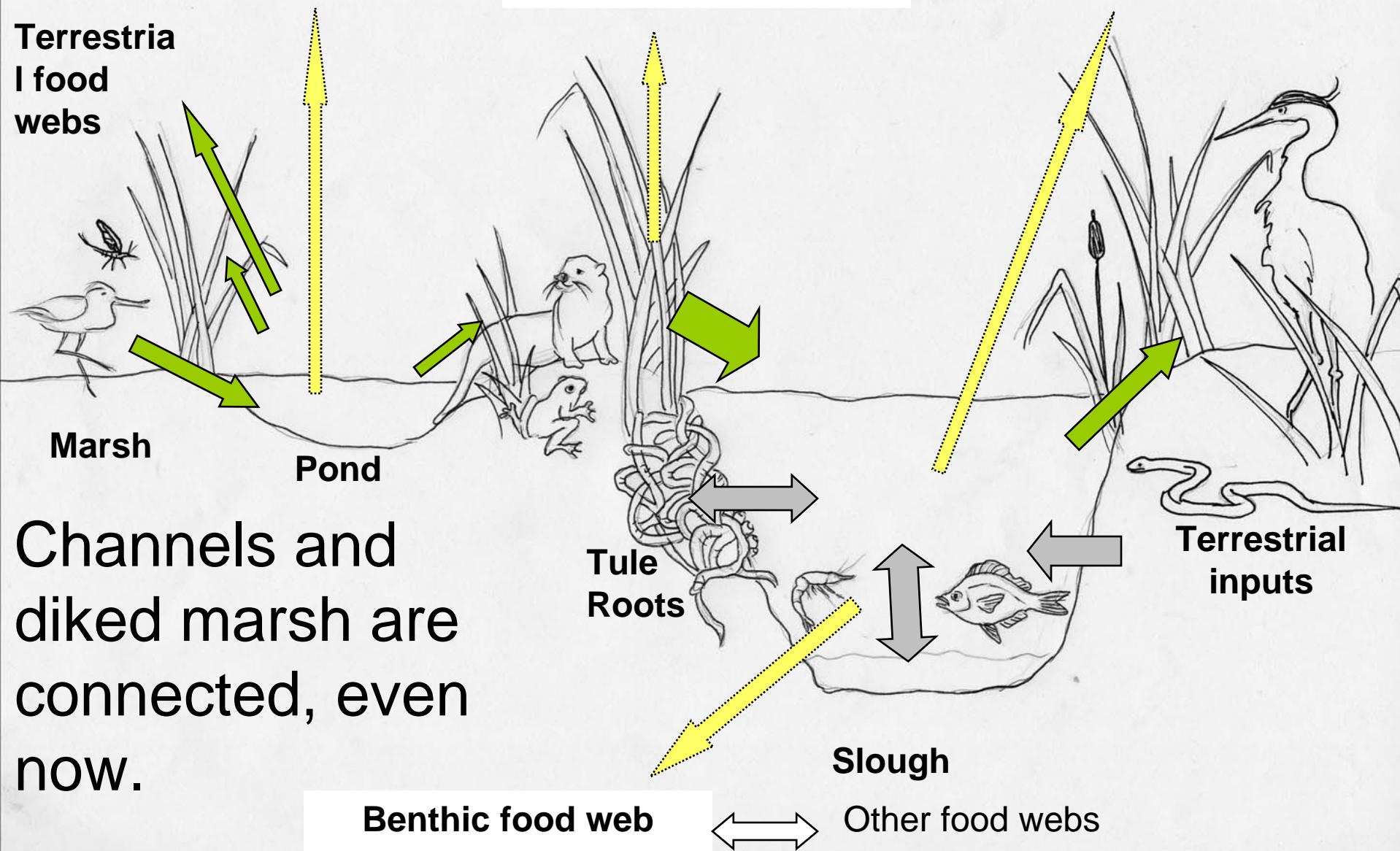
Benthic food web

Slough

Other food webs

Tule Roots

Terrestrial inputs



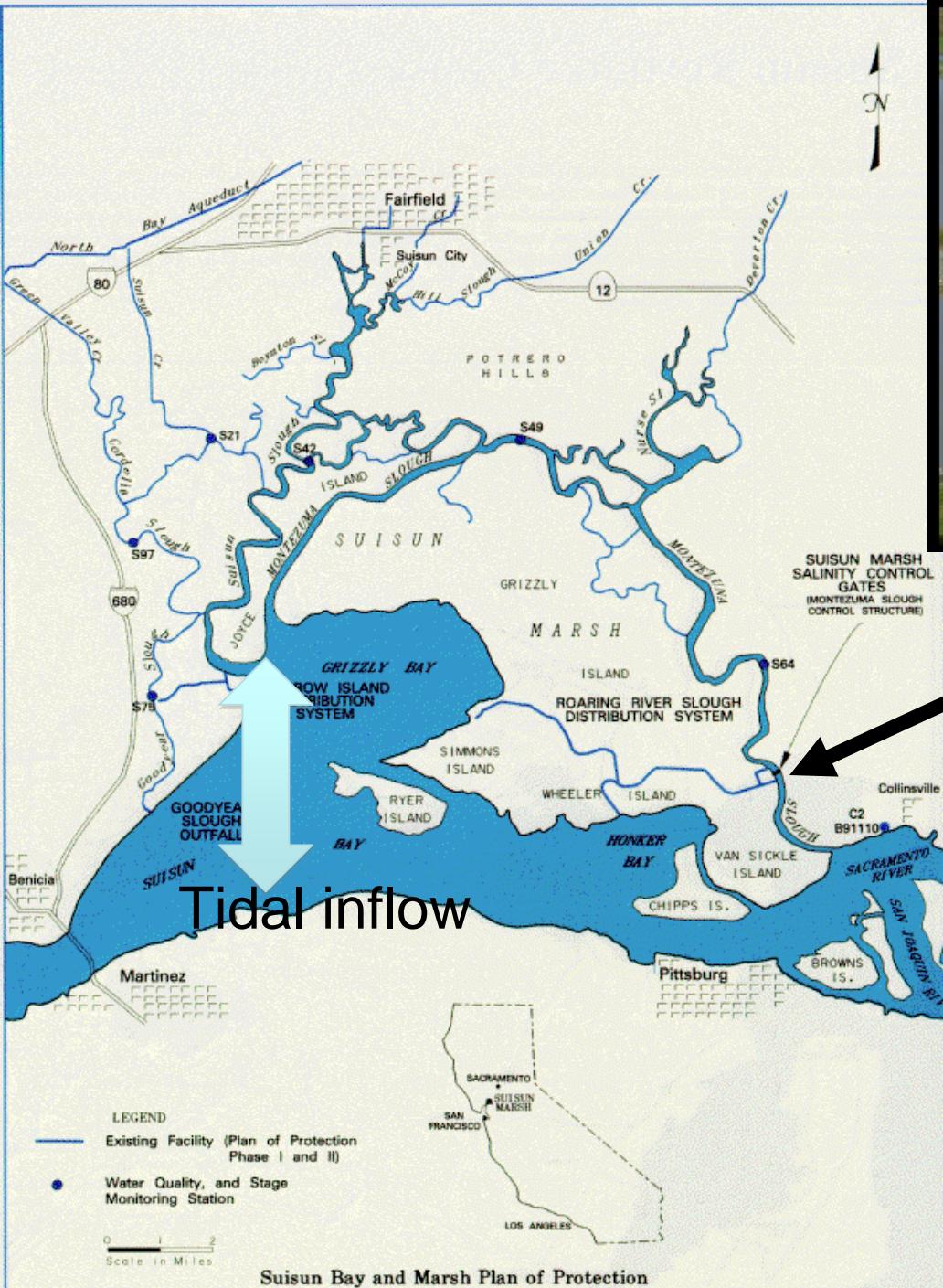
HIGHLY MANAGED SYSTEM, ON THE EDGE OF CHANGE

FRESH WATER

DUCK HUNTING CLUB

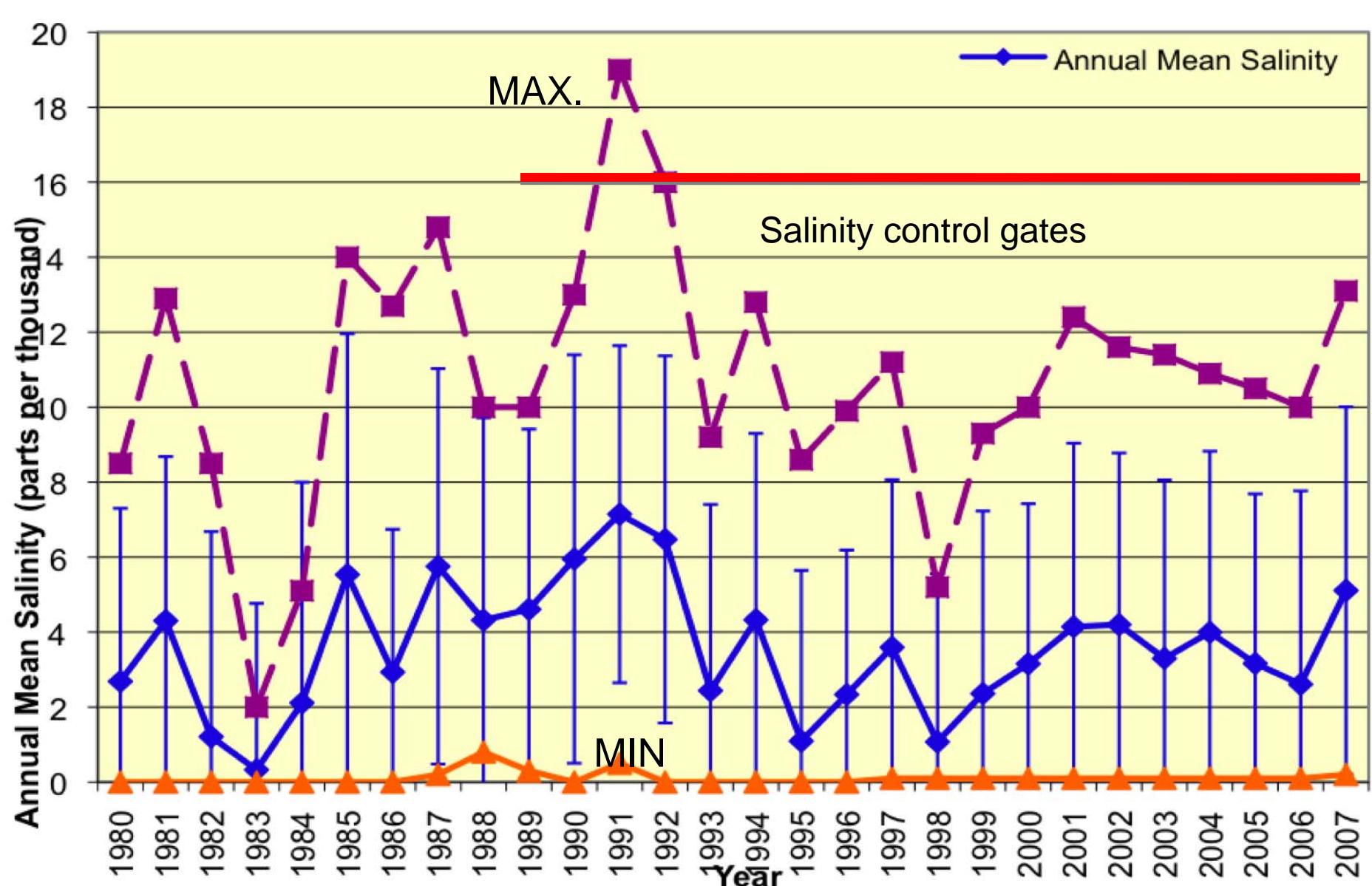


BRACKISH WATER SLOUGH
HIGH TIDE



Suisun Marsh Salinity Control Gates 1989

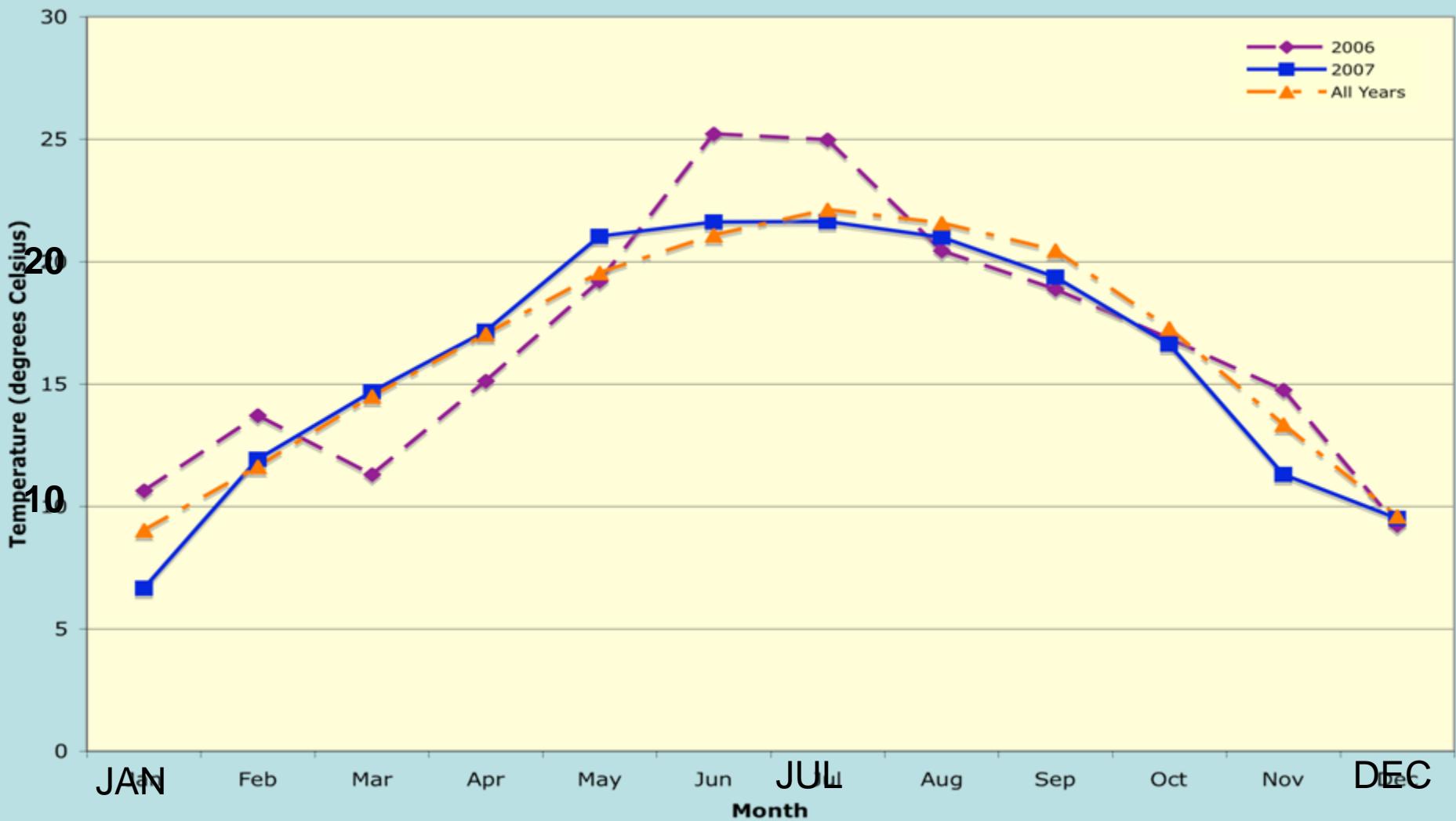
Sacramento River inflow



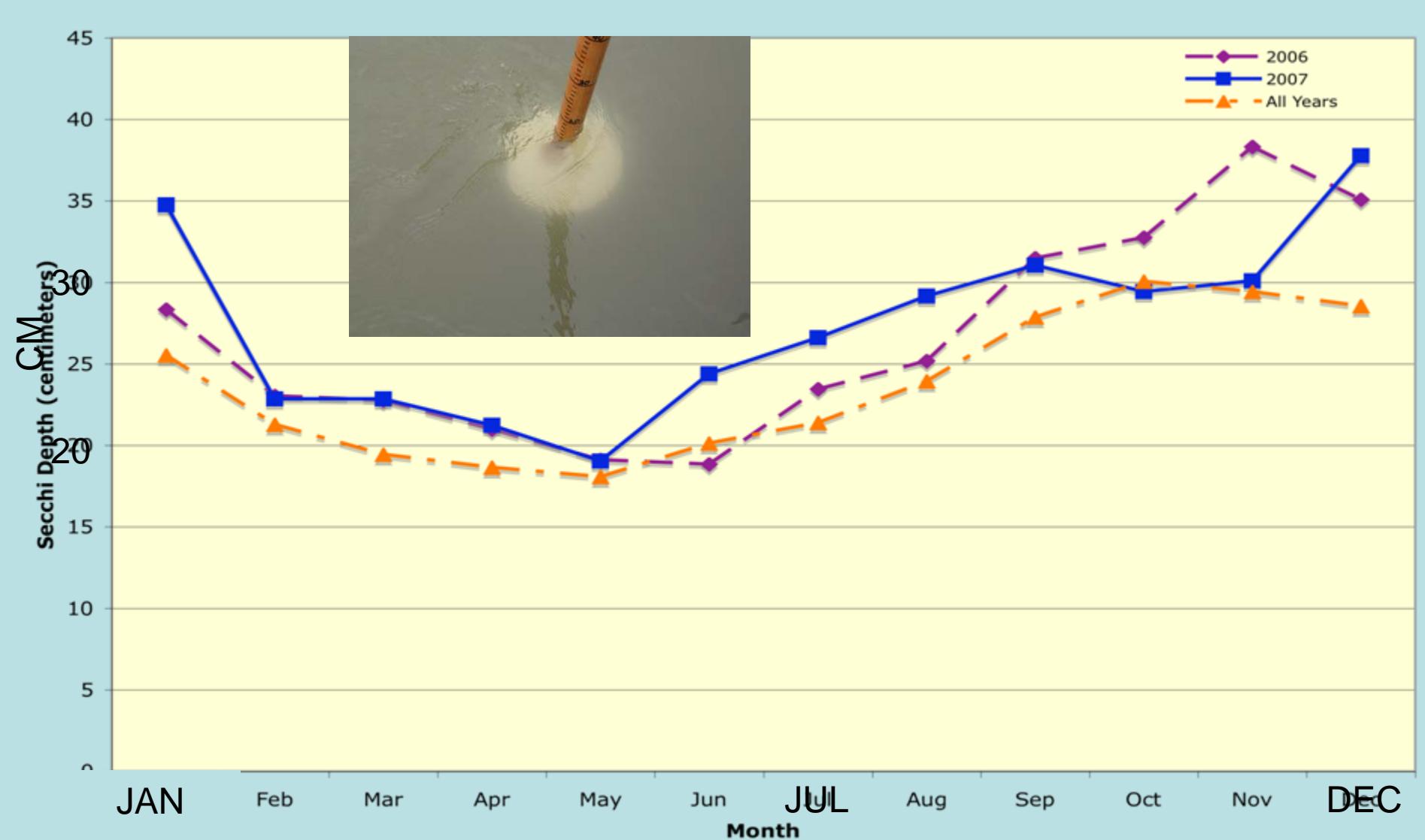
Salinity , Suisun Marsh, 1980-2007

FRESHWATER INFLOW IS A DRIVING VARIABLE

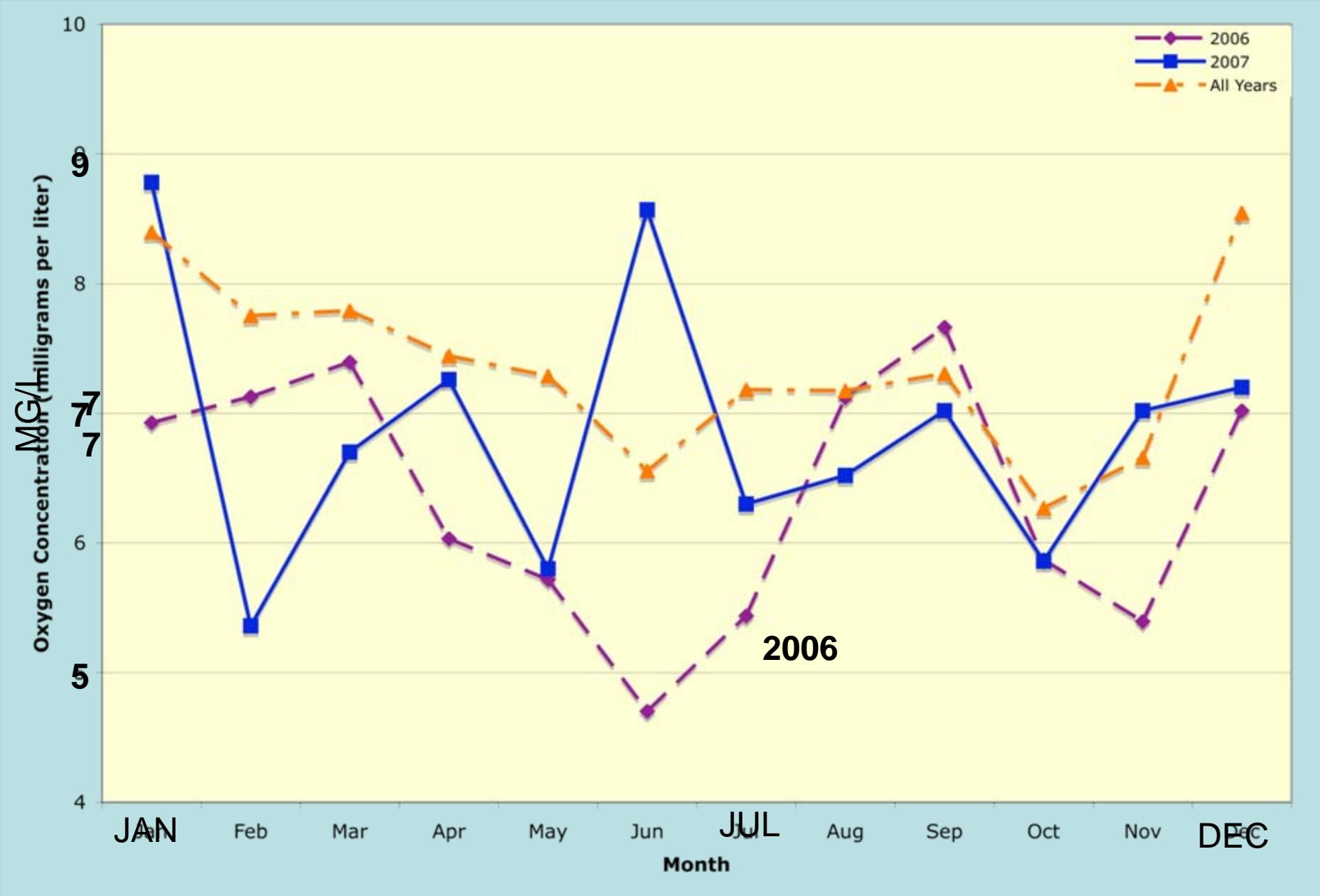




Daytime Temperatures, Suisun Marsh (6-25 C)



Water clarity (Secchi Depth) Suisun Marsh (20-40 cm)

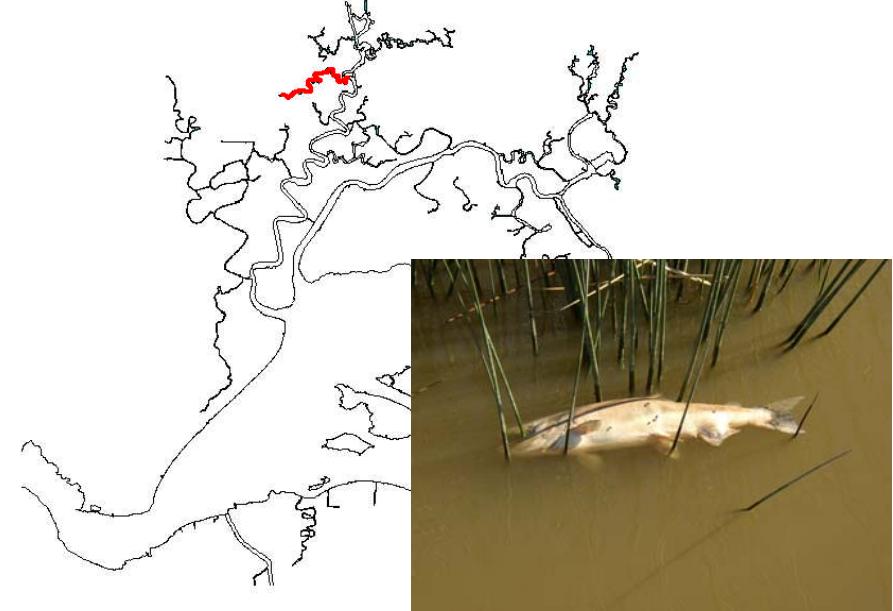
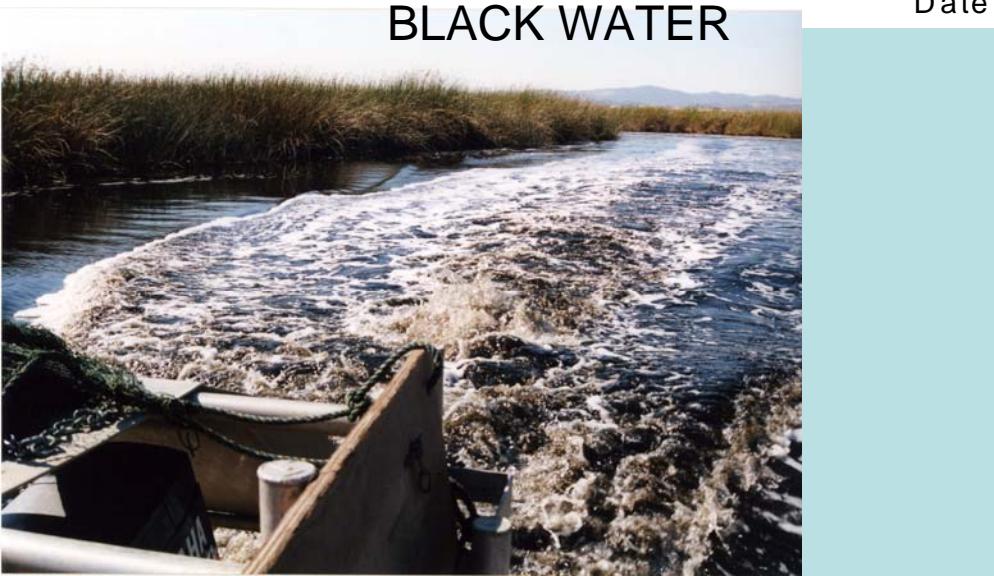
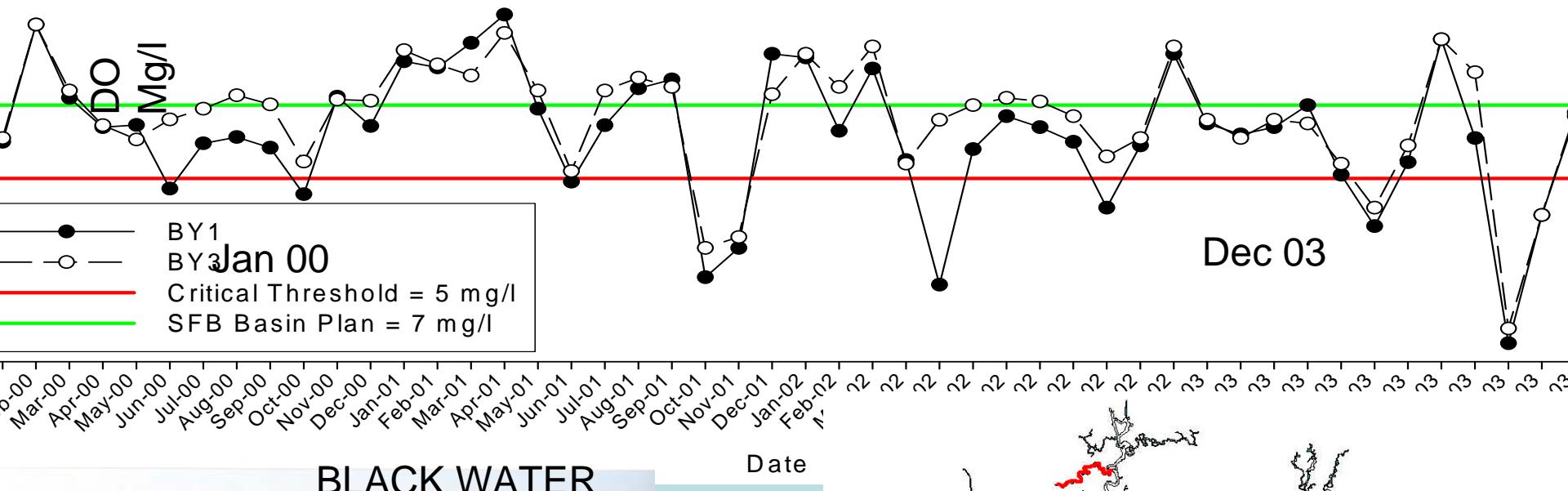


DISSOLVED OXYGEN, SUISUN MARSH

Boynton Slough

Boynton Slough Jan. 2000-Dec. 2003

Suisun Marsh low dissolved oxygen events





- Goals of Suisun fish study
- Methods
- Alien invasions
- Trends in fish populations
- Trends in fish assemblages
- The future of Suisun Marsh

OFFICIAL GOALS OF UCD FISH STUDY

1980

- DETERMINE EFFECTS OF SALINITY CONTROL GATES
- MONITORING
- FUNDED BY DEPARTMENT OF WATER RESOURCES



Unofficial goals

- Biology of poorly known native fishes
 - Tule perch
 - Splittail
 - Delta smelt
- Long-term study of structure of estuarine fish assemblage
 - “No-analog assemblage”
 - 50% alien species

Unofficial Goals

- Effects of new invaders
 - Shimofuri goby
 - Overbite clam
 - Jellyfish
- Population trends in key species
- Natural vs diked sloughs as fish habitat
- Preparing for sea level rise

Unofficial goals

- Train students
- Graduate student support



Dr Randy Brown 1937-2006



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Monthly
since 1980
(warm-up
Jan-Dec 1979)

7075 trawls,
210,254 fish,
1980- 2008



Methods

Trawling

5 MINUTES IN SMALL
SLOUGHS,
10 MIN IN LARGE
SLOUGHS

Methods

Seining

Monthly, two locations



1756 seine hauls, 116,911 fish,
1980-2008



Invertebrate
Sampling

Project specific

METHODS: WATER QUALITY

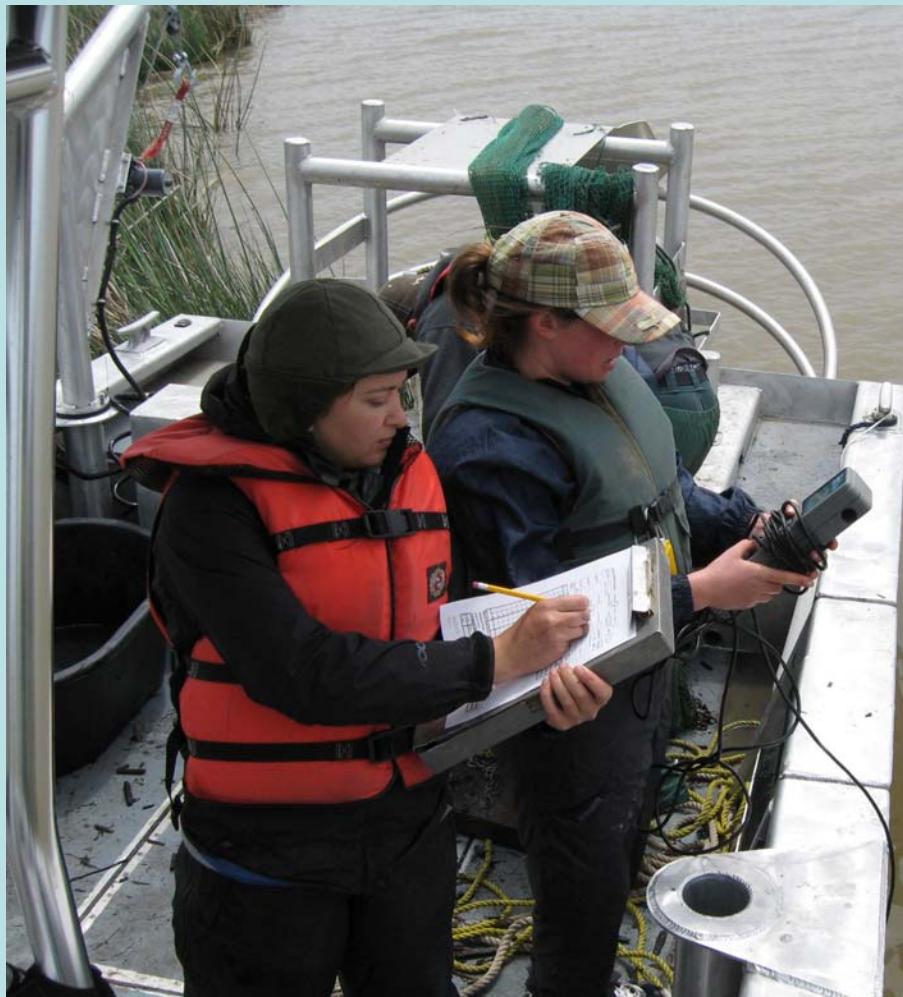
CLARITY (SECCHI DEPTH)

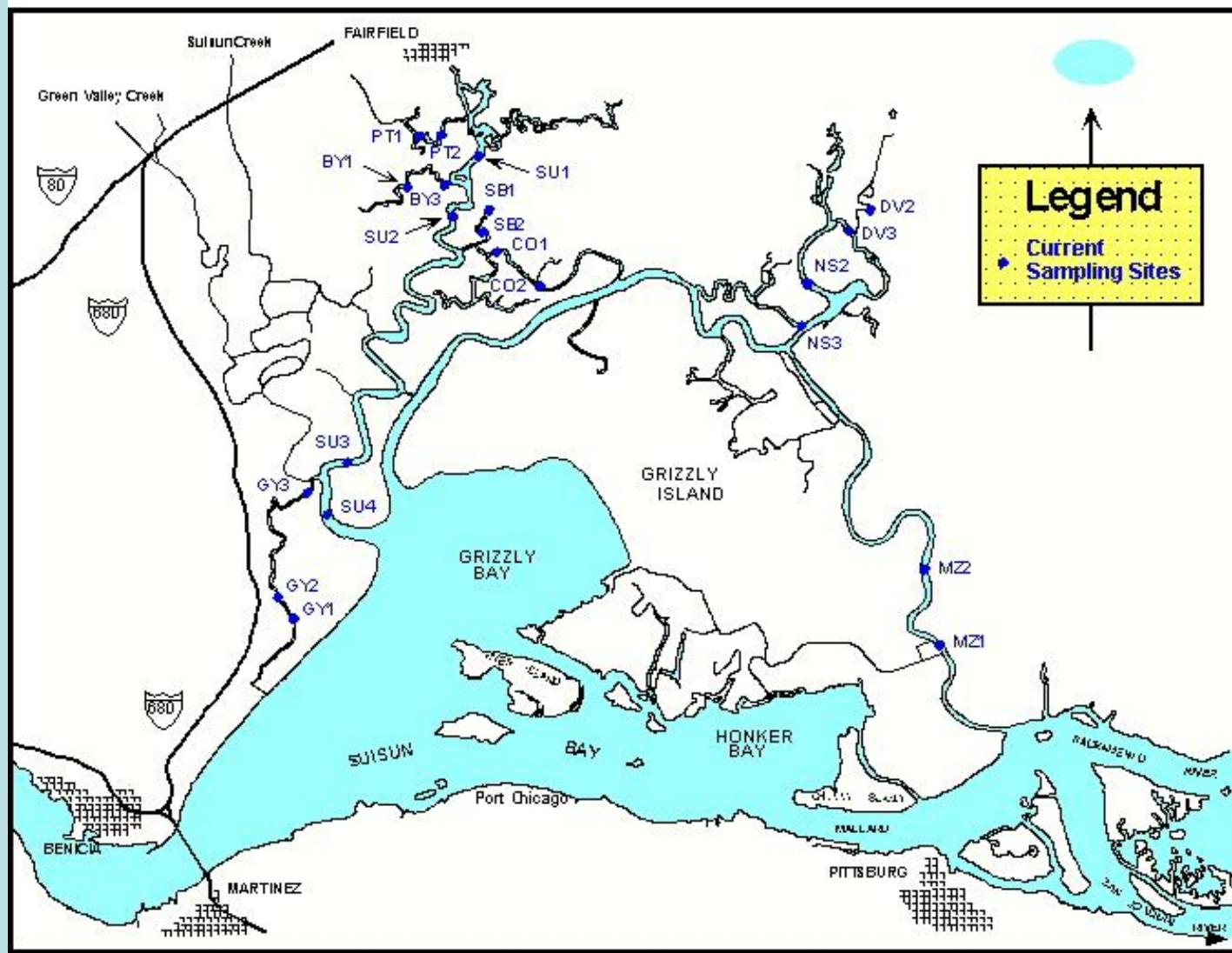
TEMPERATURE

SALINITY

CONDUCTIVITY

DISSOLVED OXYGEN





1980-94 17 sites trawled, 1 seined monthly
1994-present 21 sites trawled, 2 seined monthly



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CONCLUSIONS: WATER QUALITY

- BRACKISH, COOL WATER TIDAL SYSTEM
- VARIABILITY REDUCED IN RECENT YEARS
- LOW D.O. AN INTERMITTENT PROBLEM

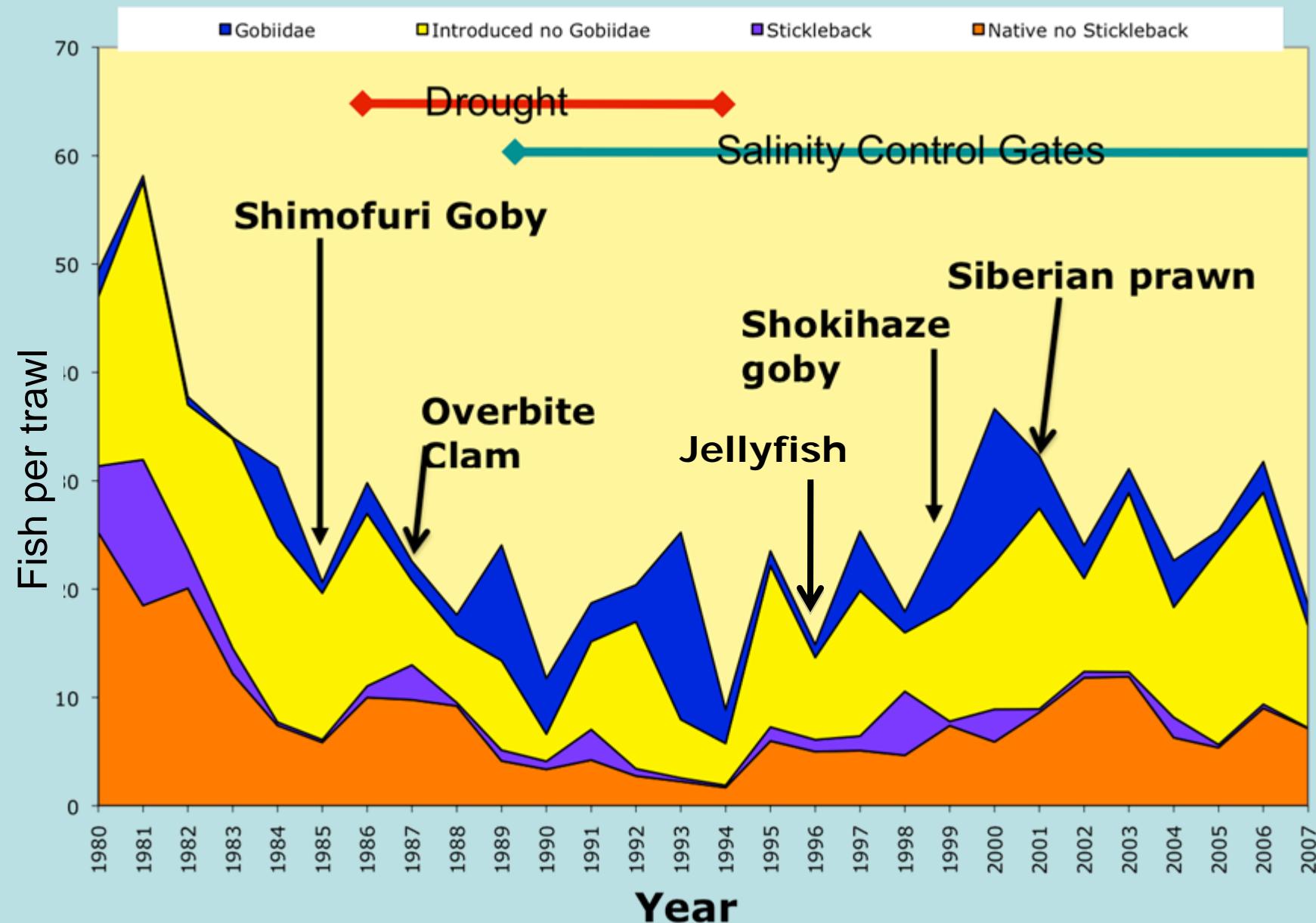




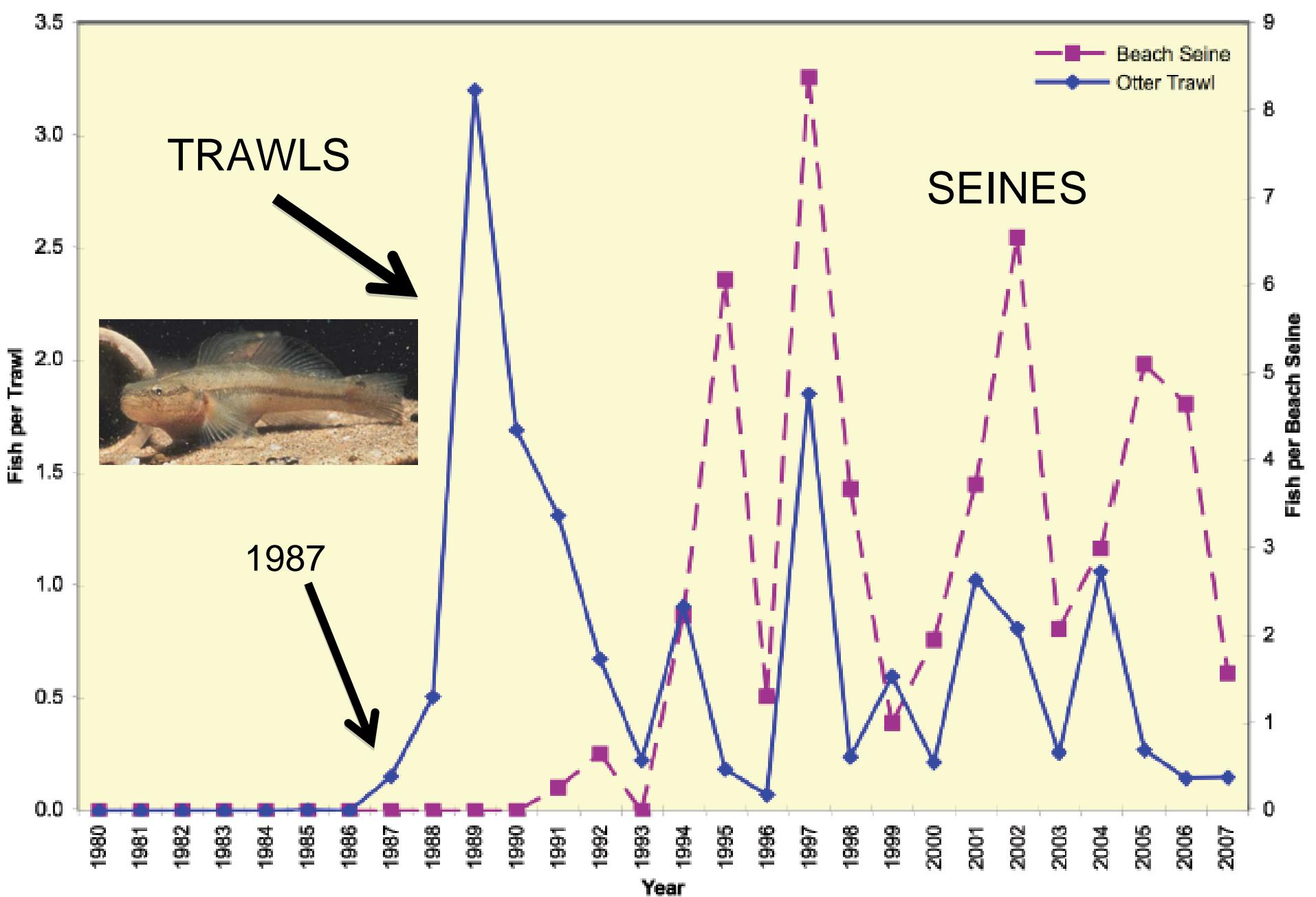
- Goals of Suisun fish study
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Major macro-invaders 1980-2009





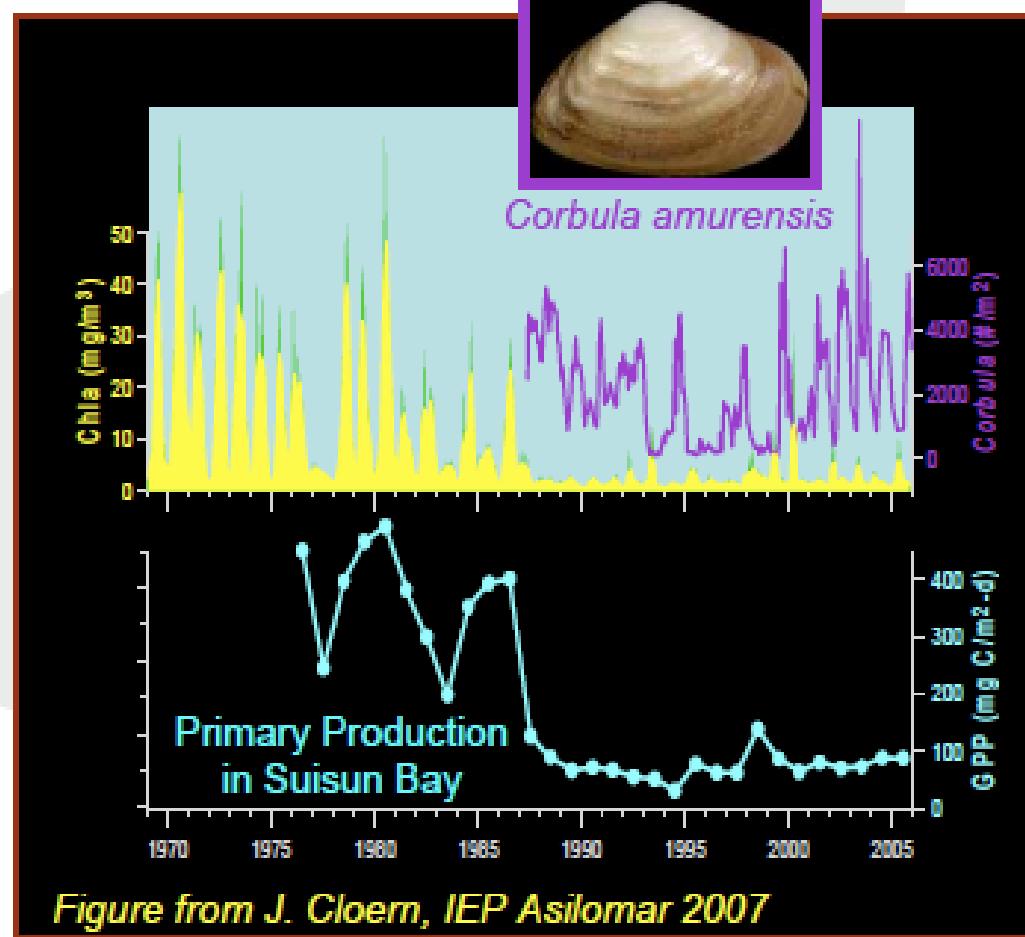
Invasions & other events, 1980-2008



SHIMOFURI GOBY 1980-2007

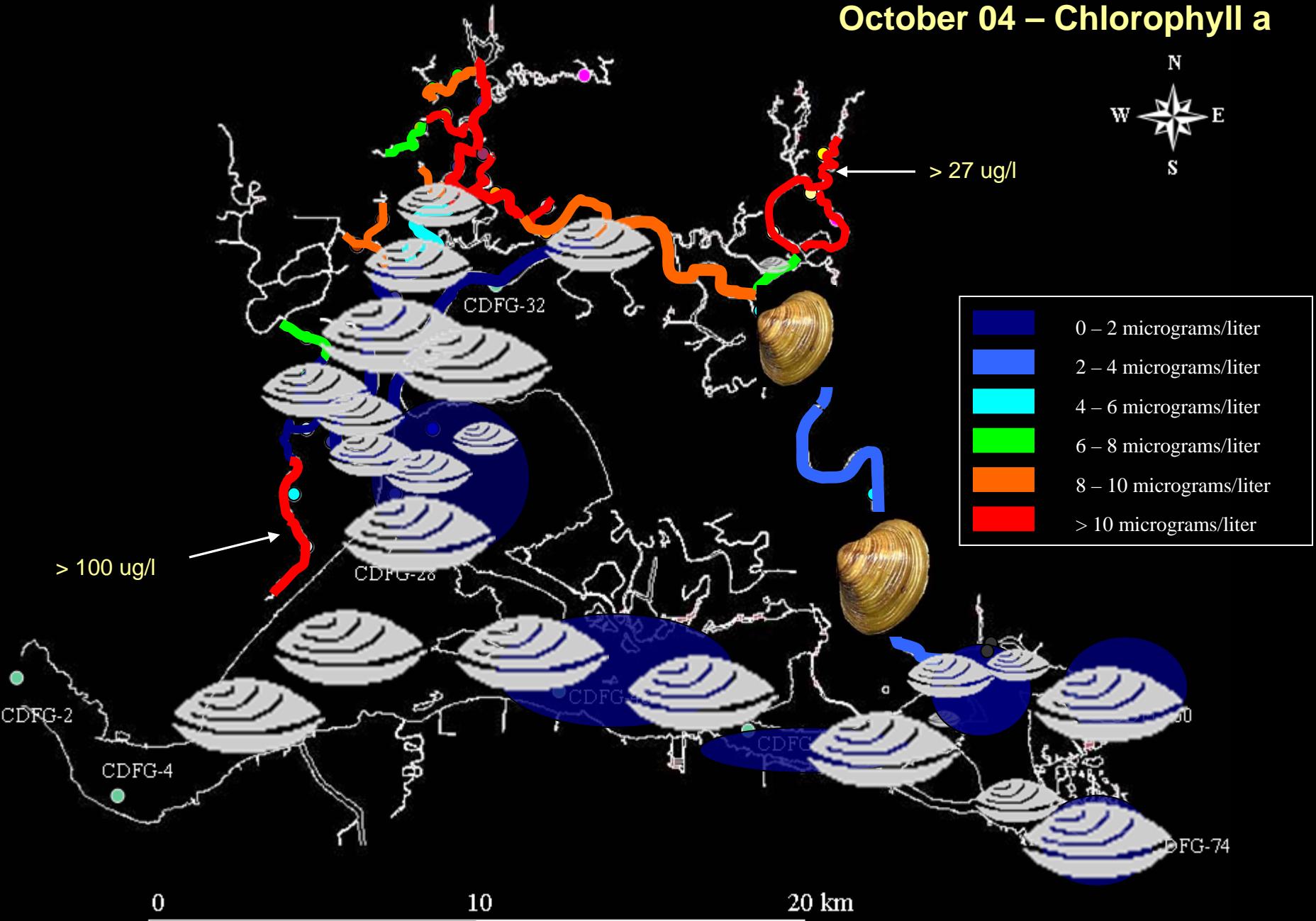
Phytoplankton Biomass & Primary Production

... CRASHED in Suisun Bay right after the 1987 *Corbula* invasion

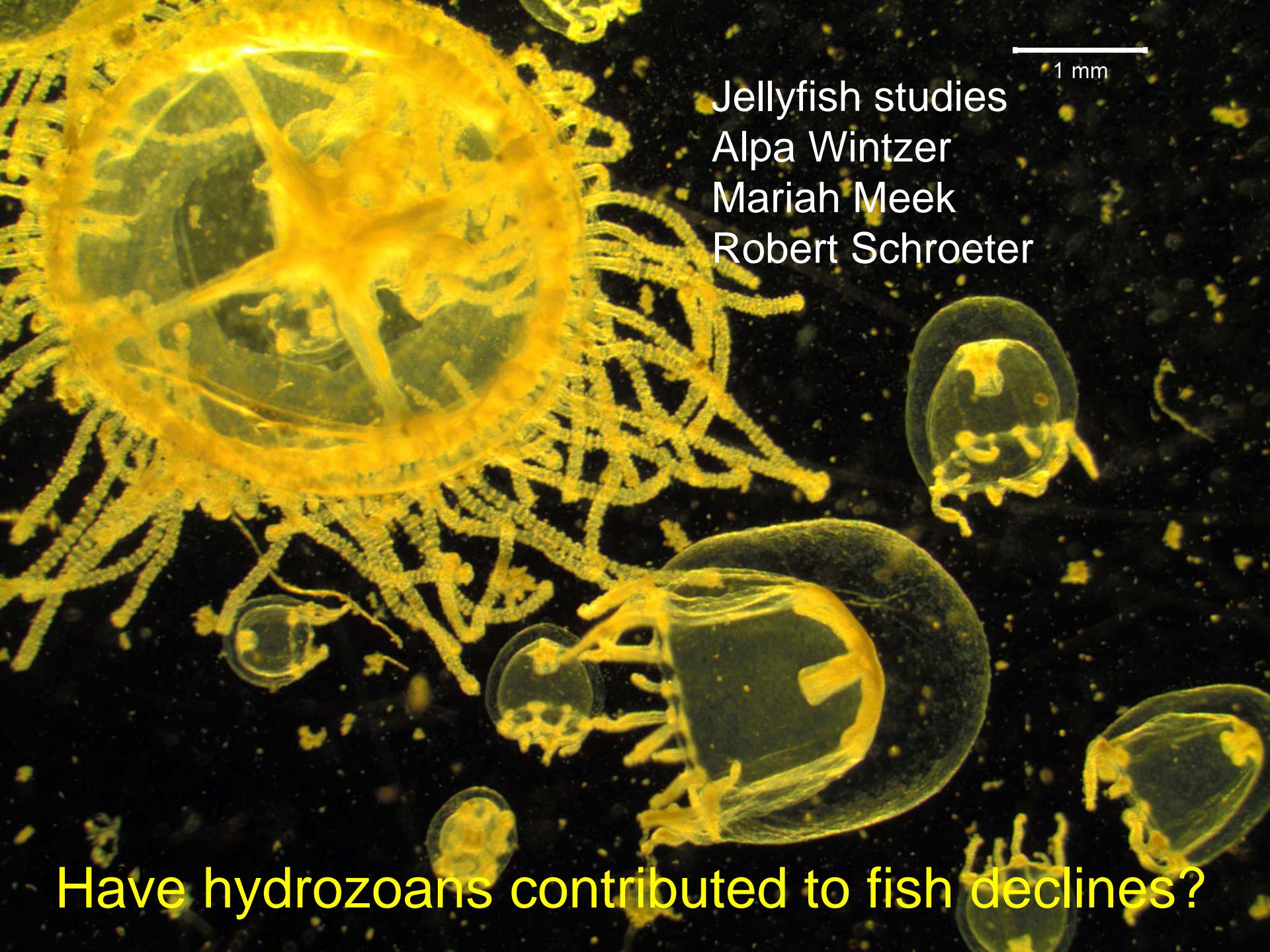


THANKS TO ANKE MUELLER-SOLGER & JIM CLOERN

October 04 – Chlorophyll a



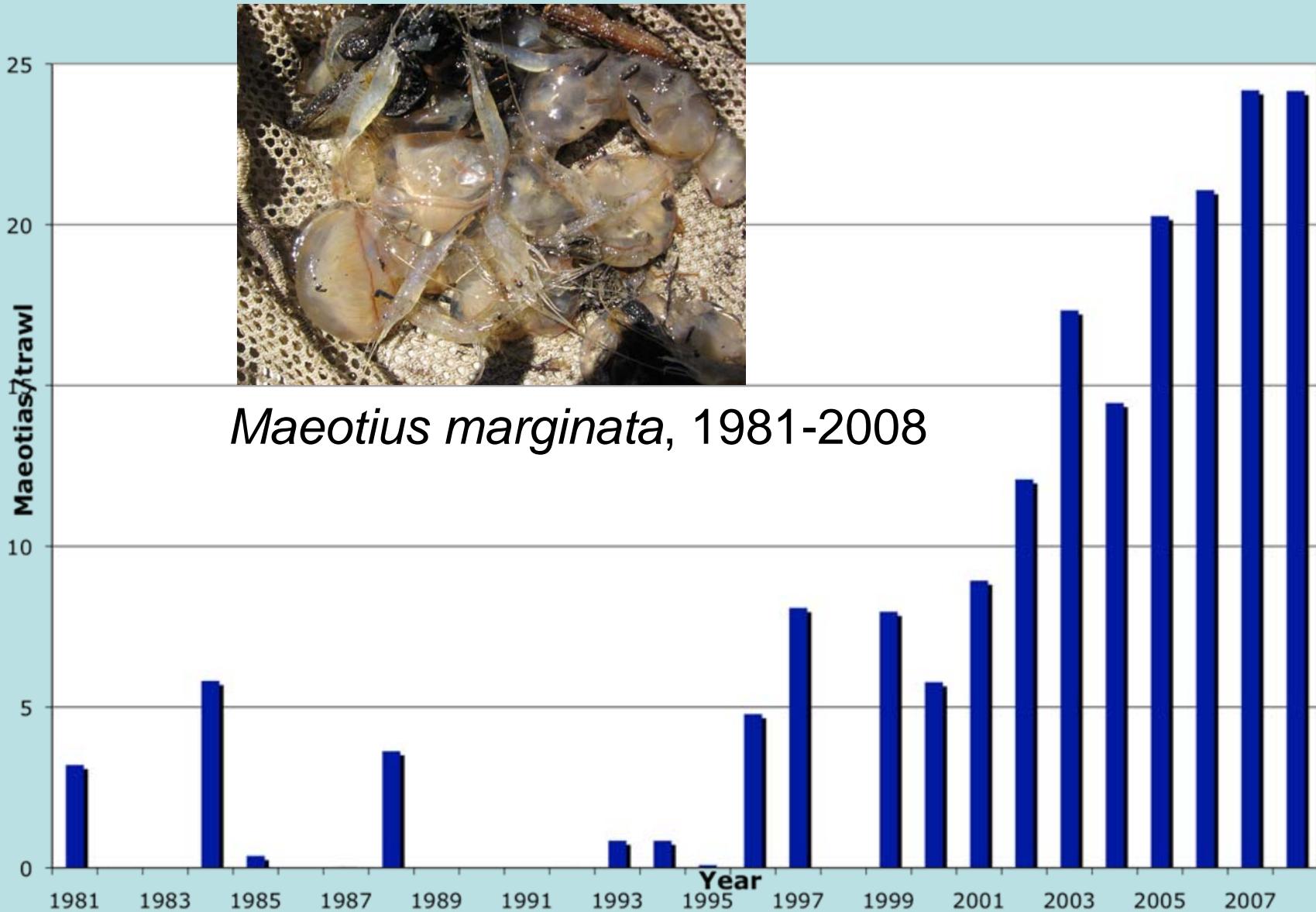
ROBERT SCHROETER

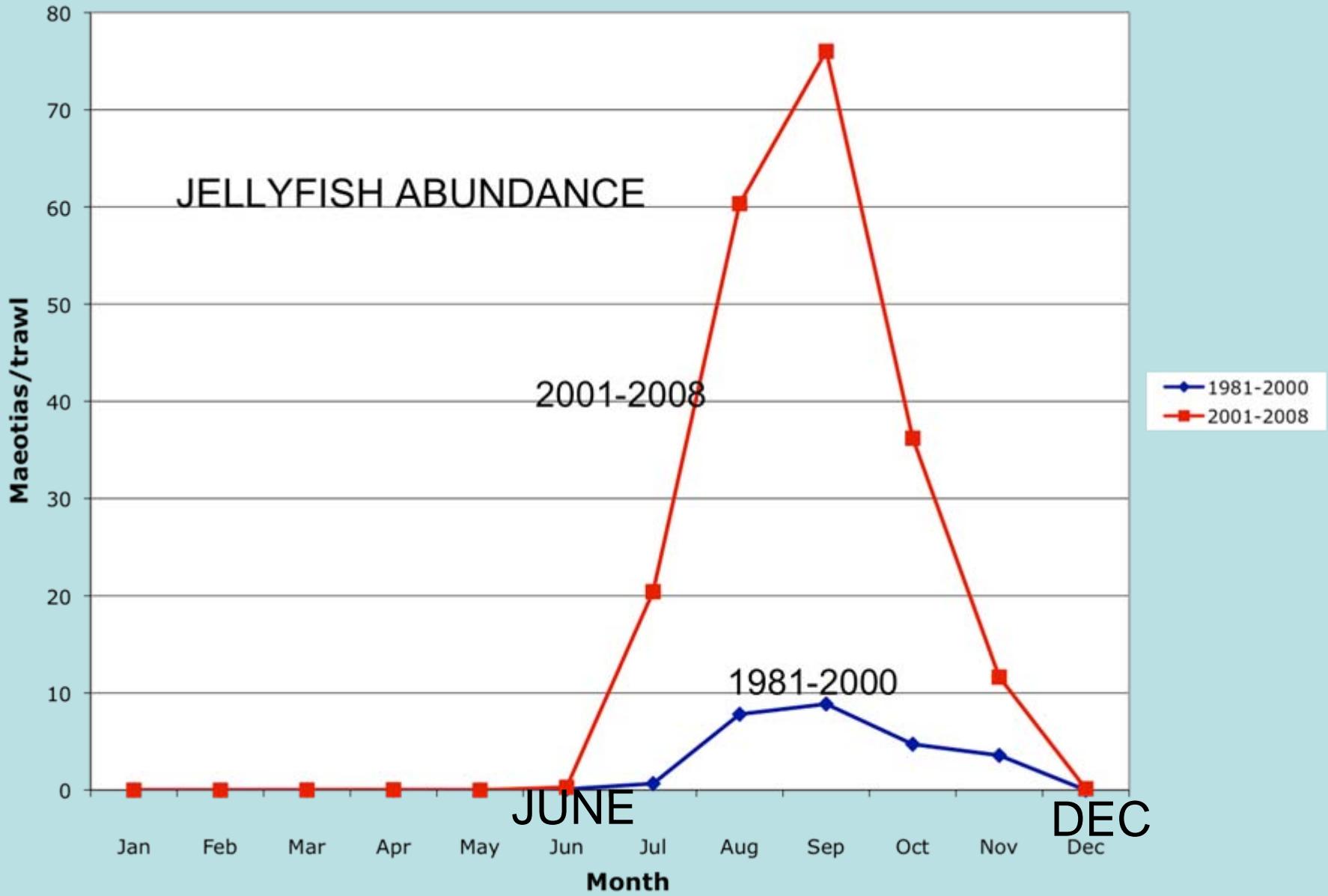


1 mm

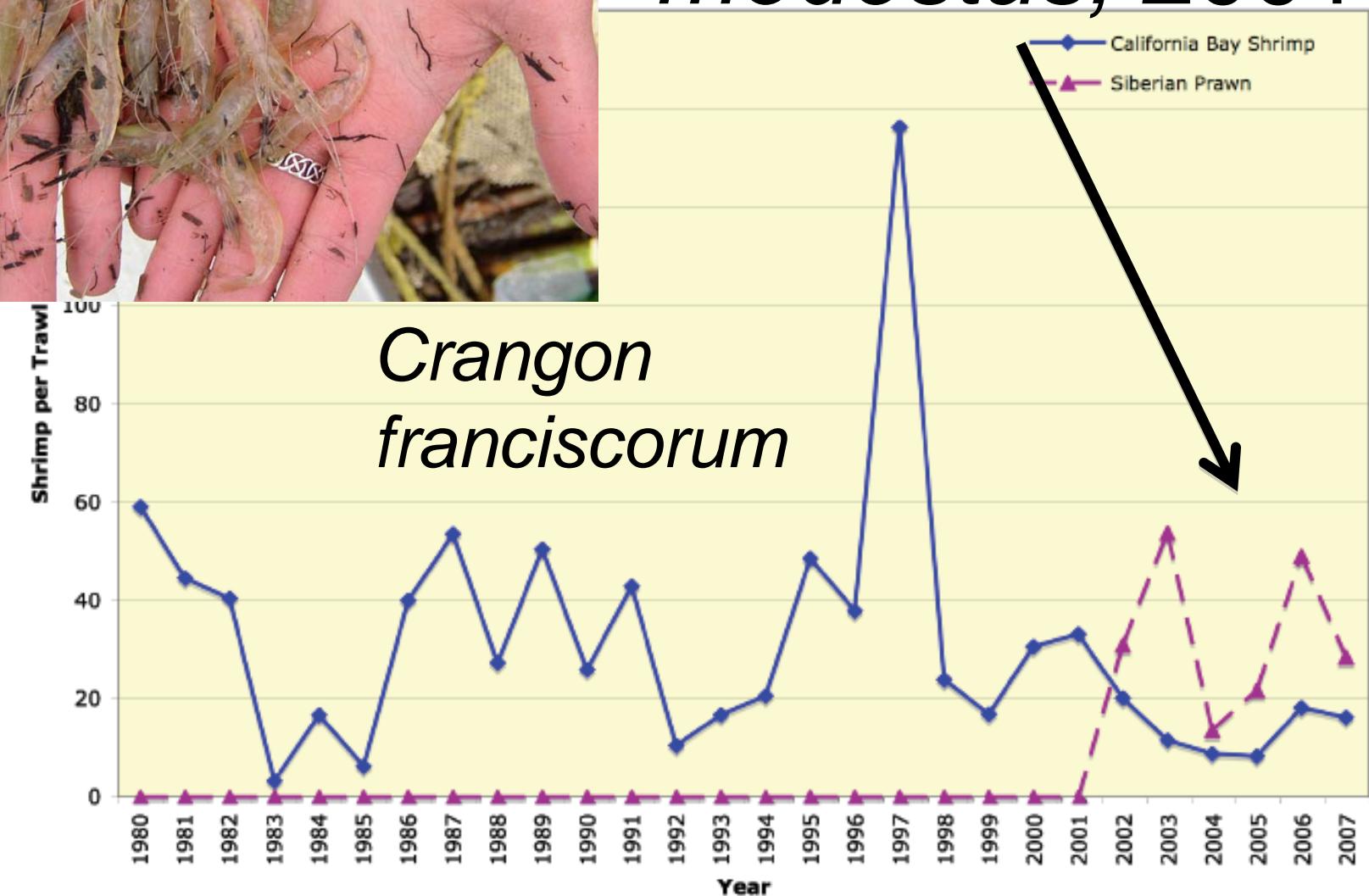
Jellyfish studies
Alpa Wintzer
Mariah Meek
Robert Schroeter

Have hydrozoans contributed to fish declines?





Siberian prawn *Exopaleomon modestus*, 2001



CONCLUSIONS: ALIENS

- ALIENS INCREASING IN RECENT YEARS
- NEW INVASIONS FREQUENT
 - SOME CAUSE MAJOR CHANGES
 - SOME HAVE LOW IMPACT
- ALIENS CAN BE DOMINANT PLAYERS





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Log Ann, Trawl YOY CPUS

2.00

1.50

1.00

0.50

0.00

-0.50

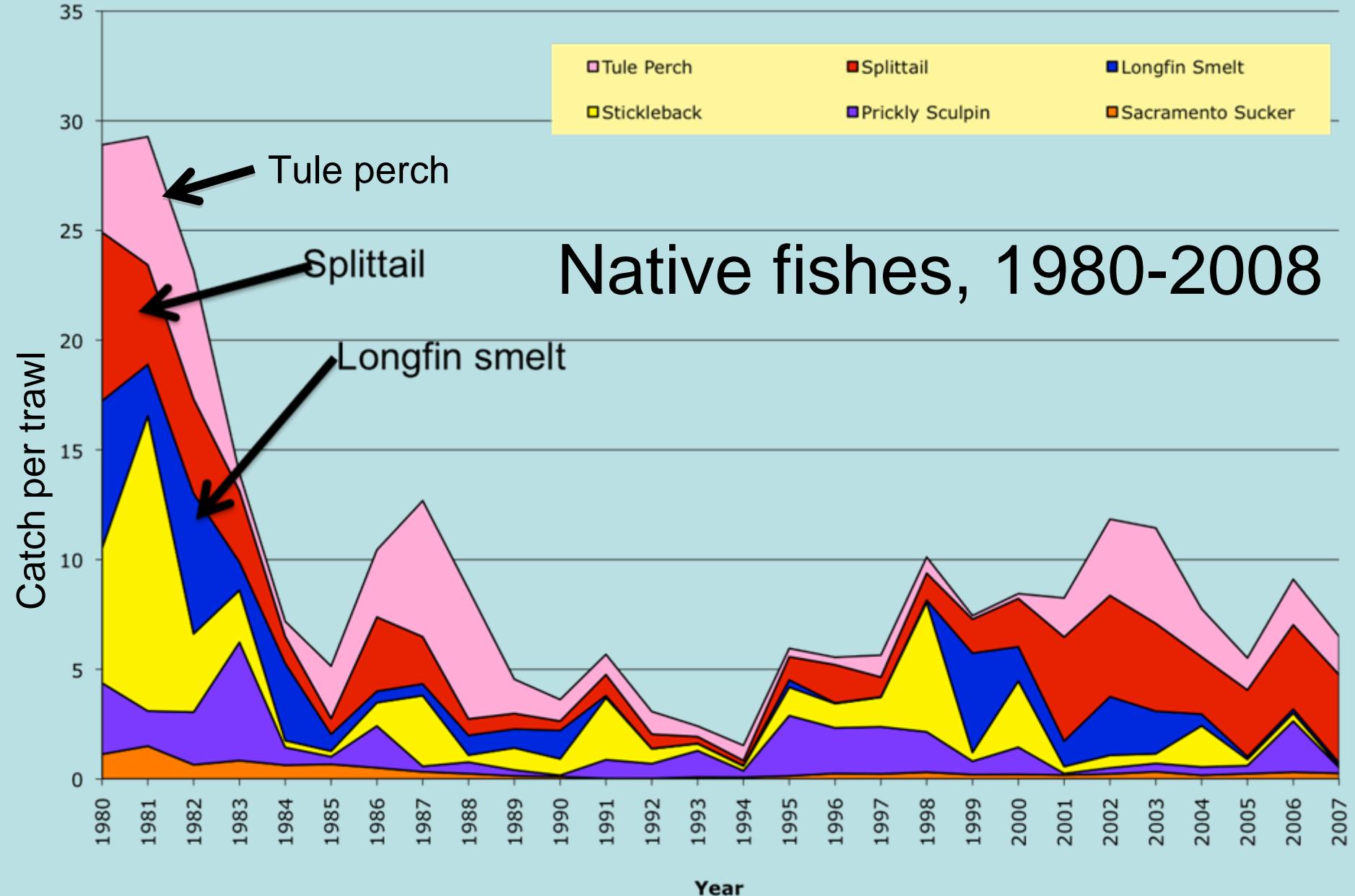
-1.00

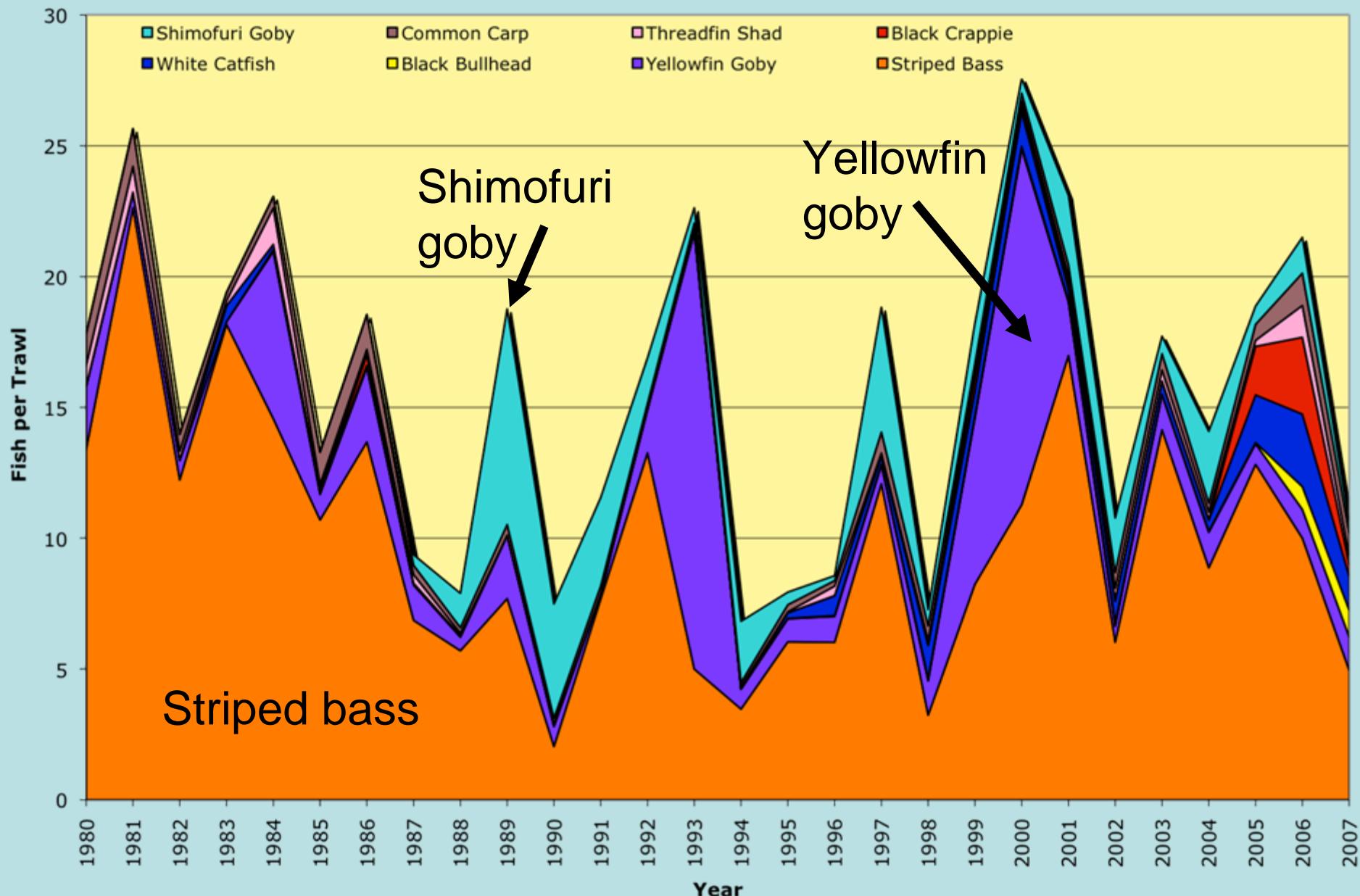
Log Ave Delta spring inflow (Feb-May)



$R^2 = 0.27103$

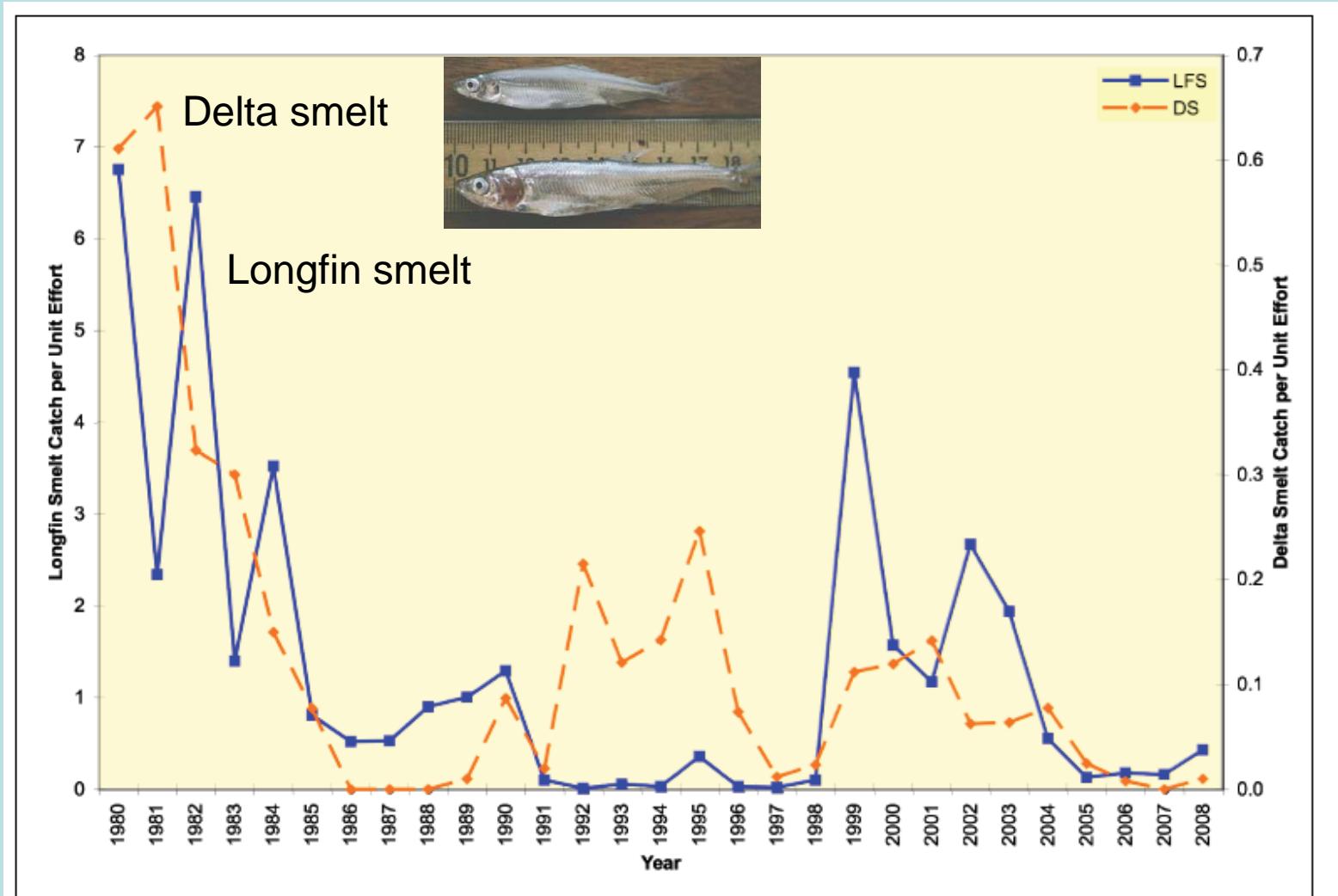
Splittail vs Inflow



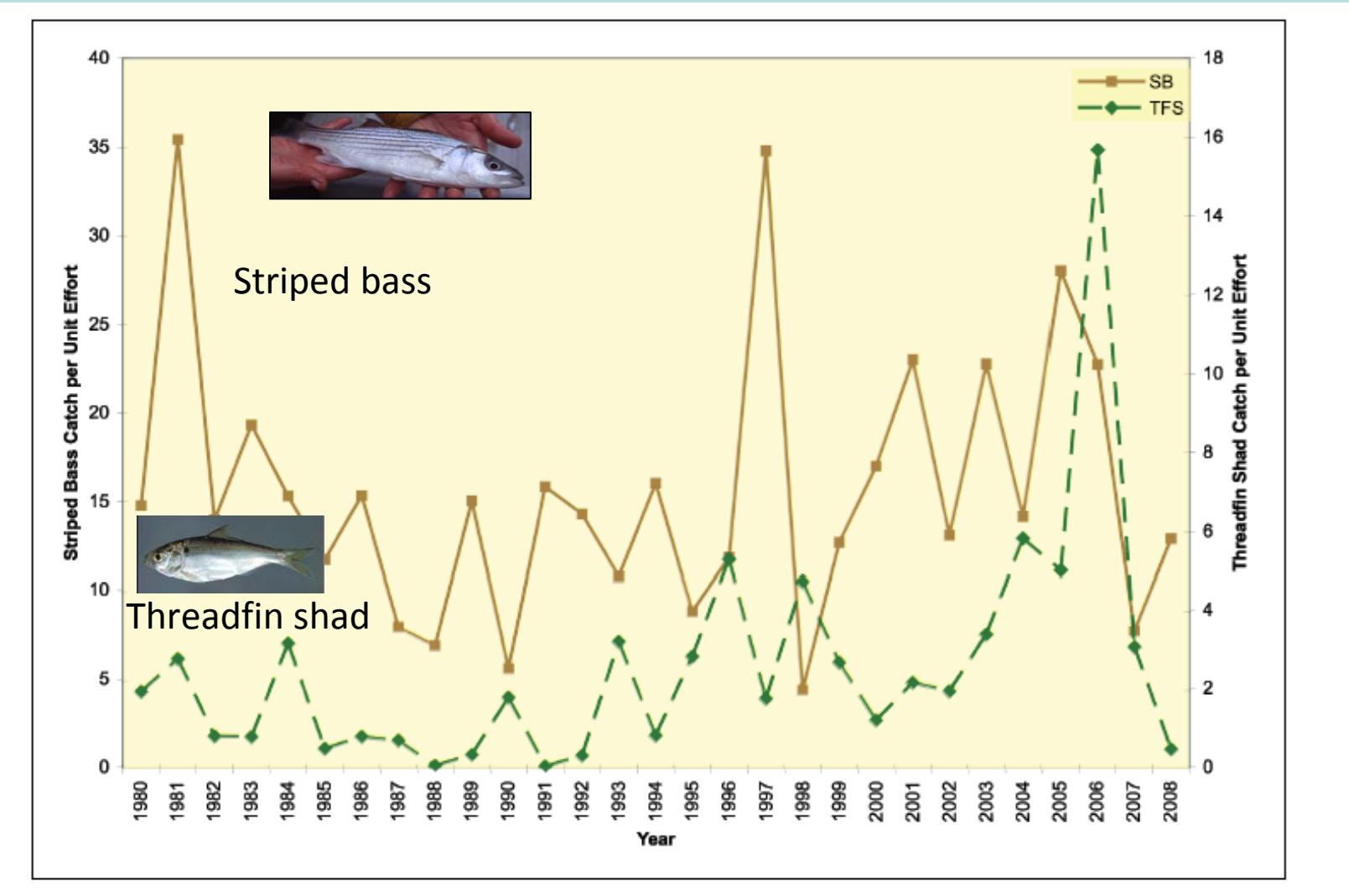


ALIEN FISHES 1980-2007

POD(?) Suisun Marsh, 1980-2008



POD(?), Suisun Marsh, 1980-2008



Why the difference between Delta and Suisun Marsh in the POD?

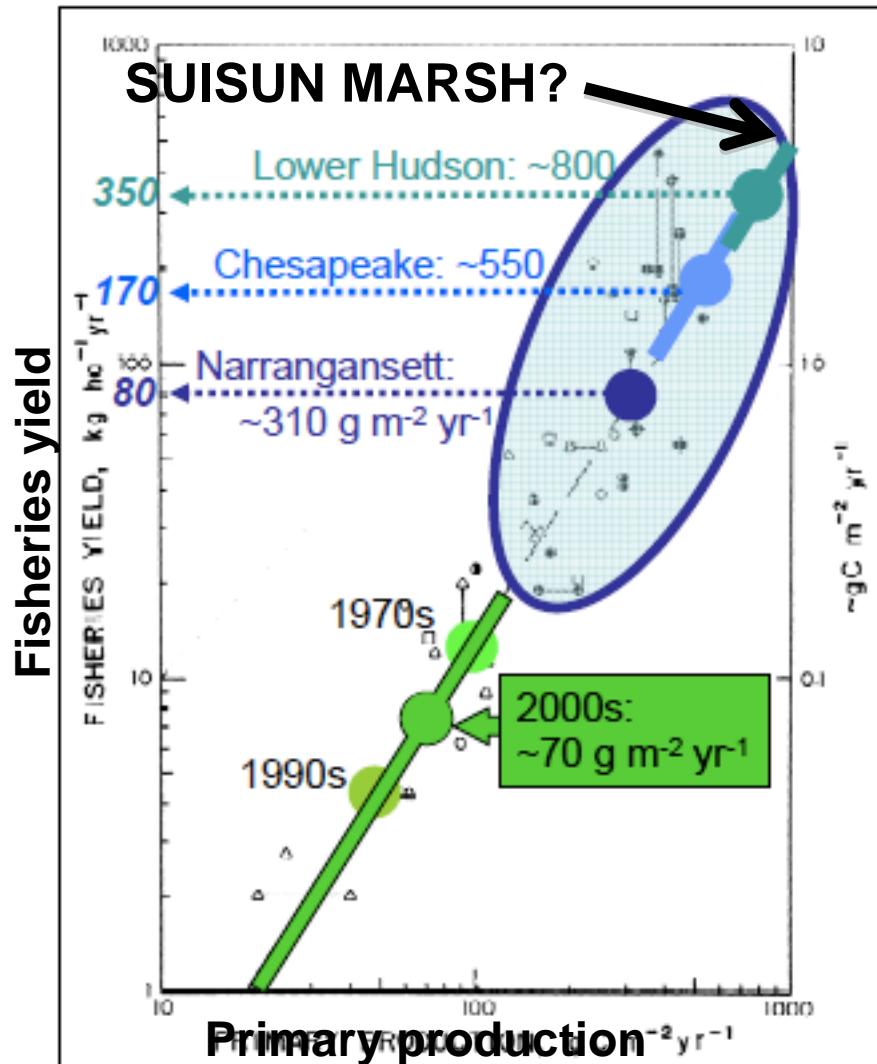
- Under investigation
- More zooplankton in marsh
- Fewer clams
- Higher productivity (more natural system)



Phytoplankton Primary Production

... in the Delta & Suisun Bay is lower than in other estuaries, and has DECLINED except Suisun Marsh?

Thanks to Anke Mueller-Solger



Sources: A. Jassby (UCD), J. Cloern (USGS), IEP data

CONCLUSIONS: FISH POPULATIONS

- NATIVES IN GENERAL DECLINE SINCE 1980S
 - MAJOR DECLINE 1980-1994
 - MULTIPLE CAUSES
- NOT ALL POD ORGANISMS IN DECLINE IN SUISUN MARSH
- HIGHER PRODUCTIVITY MAKES MARSH MAJOR NURSERY AREA(?)



- Goals of Suisun fish study
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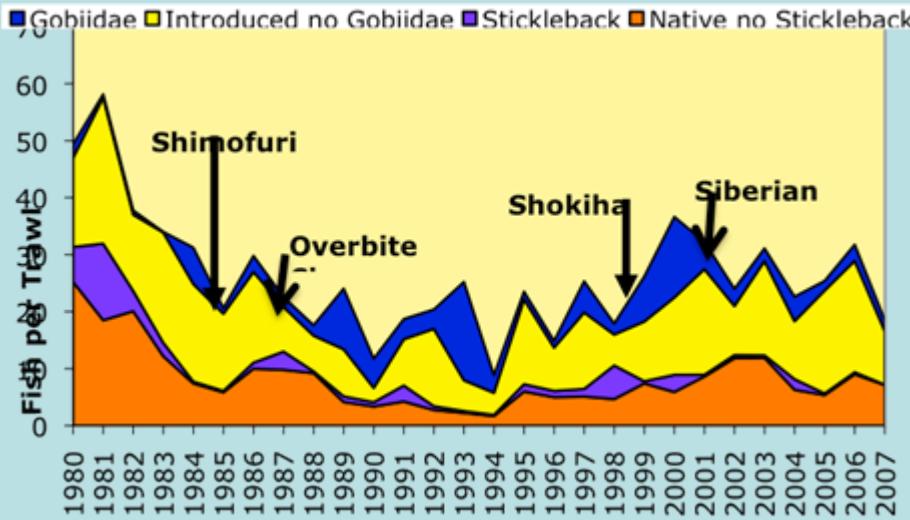
TOP TEN FISH SPECIES 1980 vs 2008

RED = ALIEN

Rank	1980	2008
1	STRIPED BASS	STRIPED BASS
2	SPLITTAIL	SPLITTAIL
3	LONGFIN SMELT	WHITE CATFISH
4	STICKLEBACK	TULE PERCH
5	TULE PERCH	STICKLEBACK
6	PRICKLY SCULPIN	COMMON CARP
7	YELLOWFIN GOBY	BLACK BULLHEAD
8	COMMON CARP	LONGFIN SMELT
9	STARRY FLOUNDER	STAGHORN SCULPIN
10	SACRAMENTO SUCKER	SHIMOFURI GOBY

ALIEN SPECIES

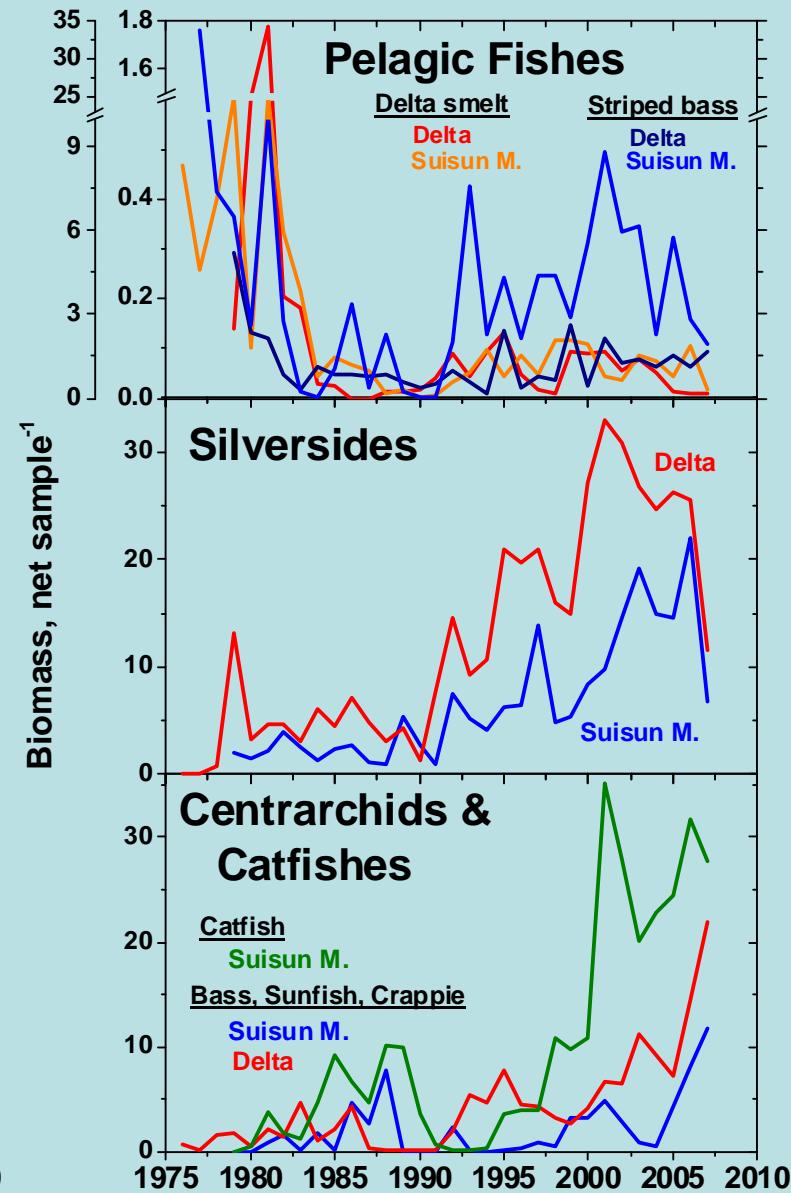
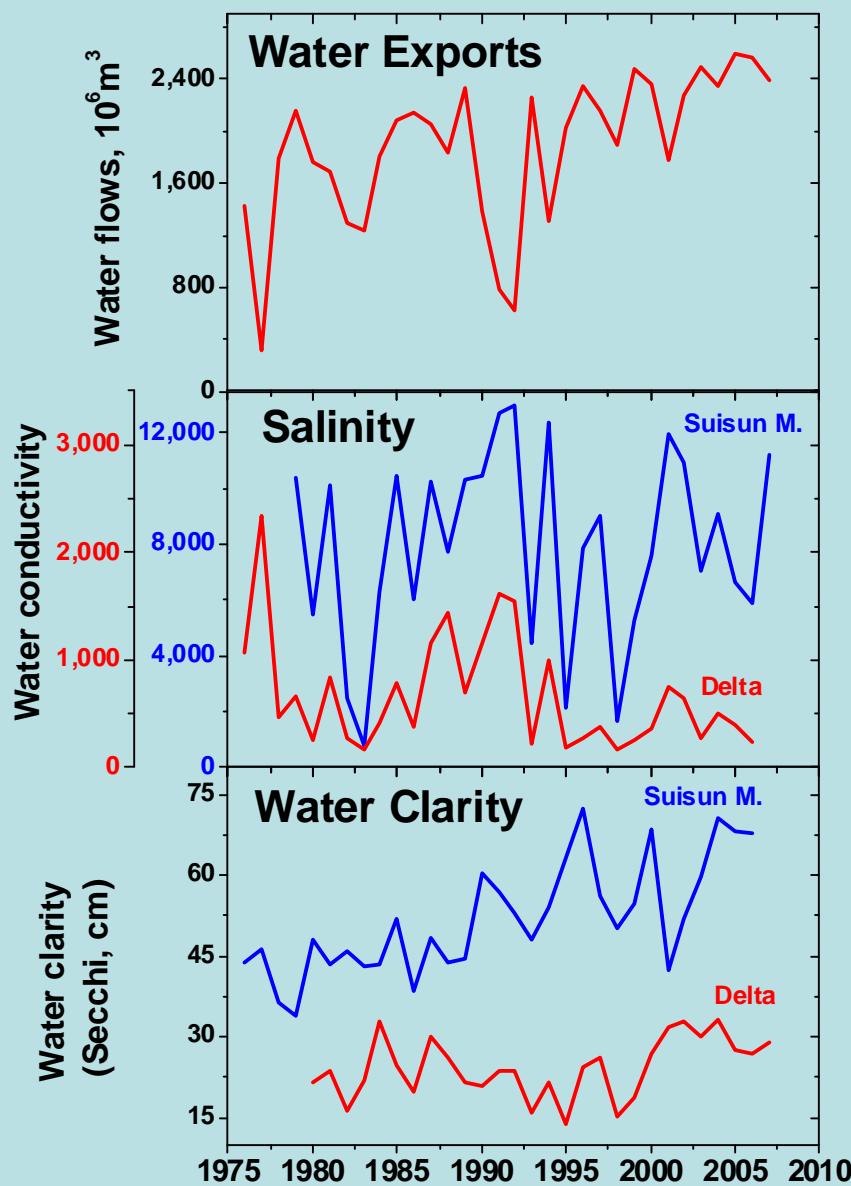
6 SPECIES IN COMMON
3 vs 6 alien species



REGIME SHIFTS IN SUISUN MARSH?

- W. A. BENNETT, BML
- REFLECT CHANGES TOWARDS LESS VARIABLE ENVIRONMENT
- MORE DOMINATED BY ALIEN SPECIES
- WILL SHIFT AGAIN

Trends in Suisun Marsh & Delta





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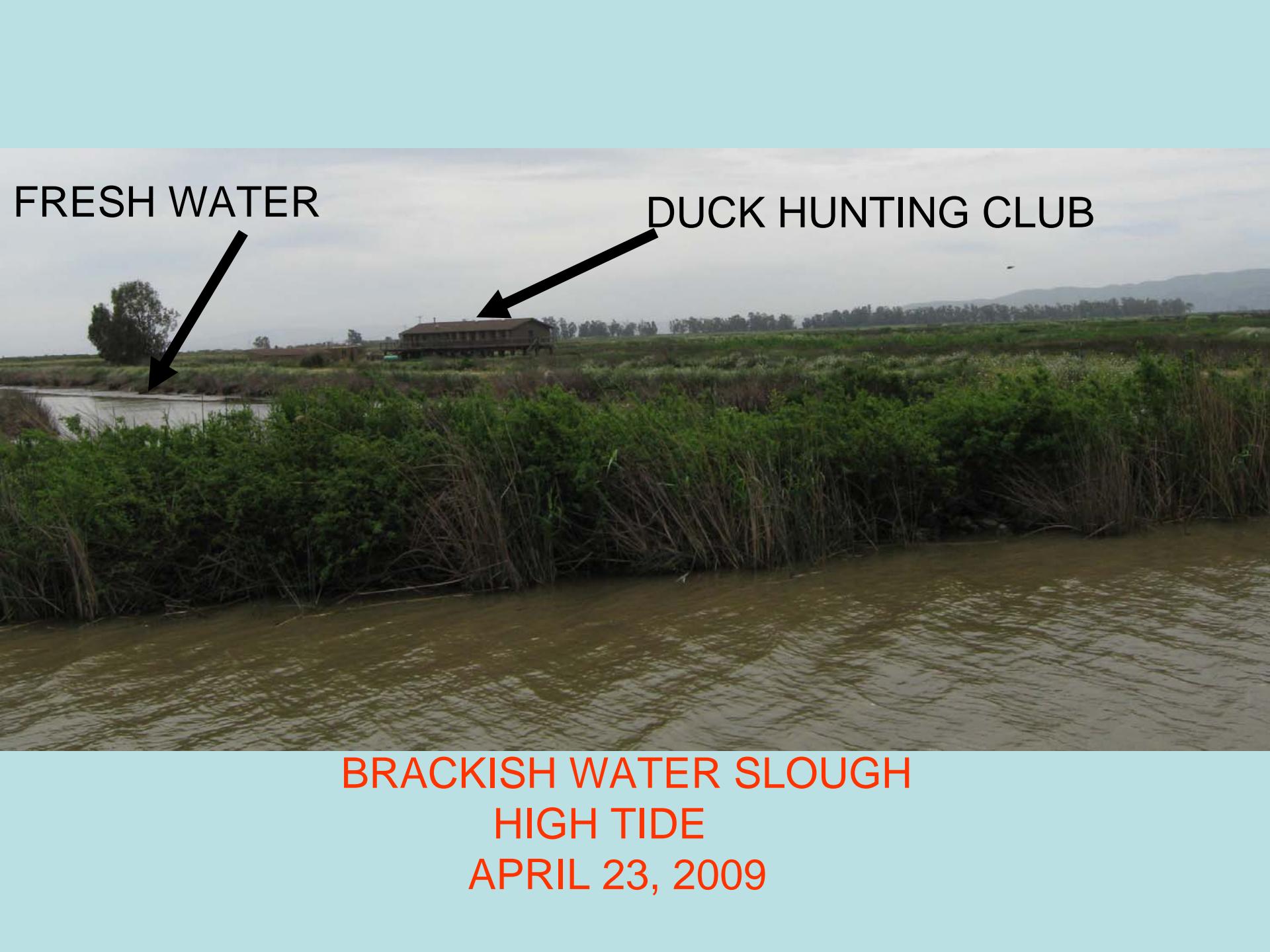
RECIPE FOR MAJOR CHANGE

- SUBSIDING LAND
- RISING SEA LEVEL
- MORE FREQUENT BIG FLOODS
- WEAK LEVEES
- EARTHQUAKES



Wheeler Island, July 2005

Suisun Marsh: earthquakes not required

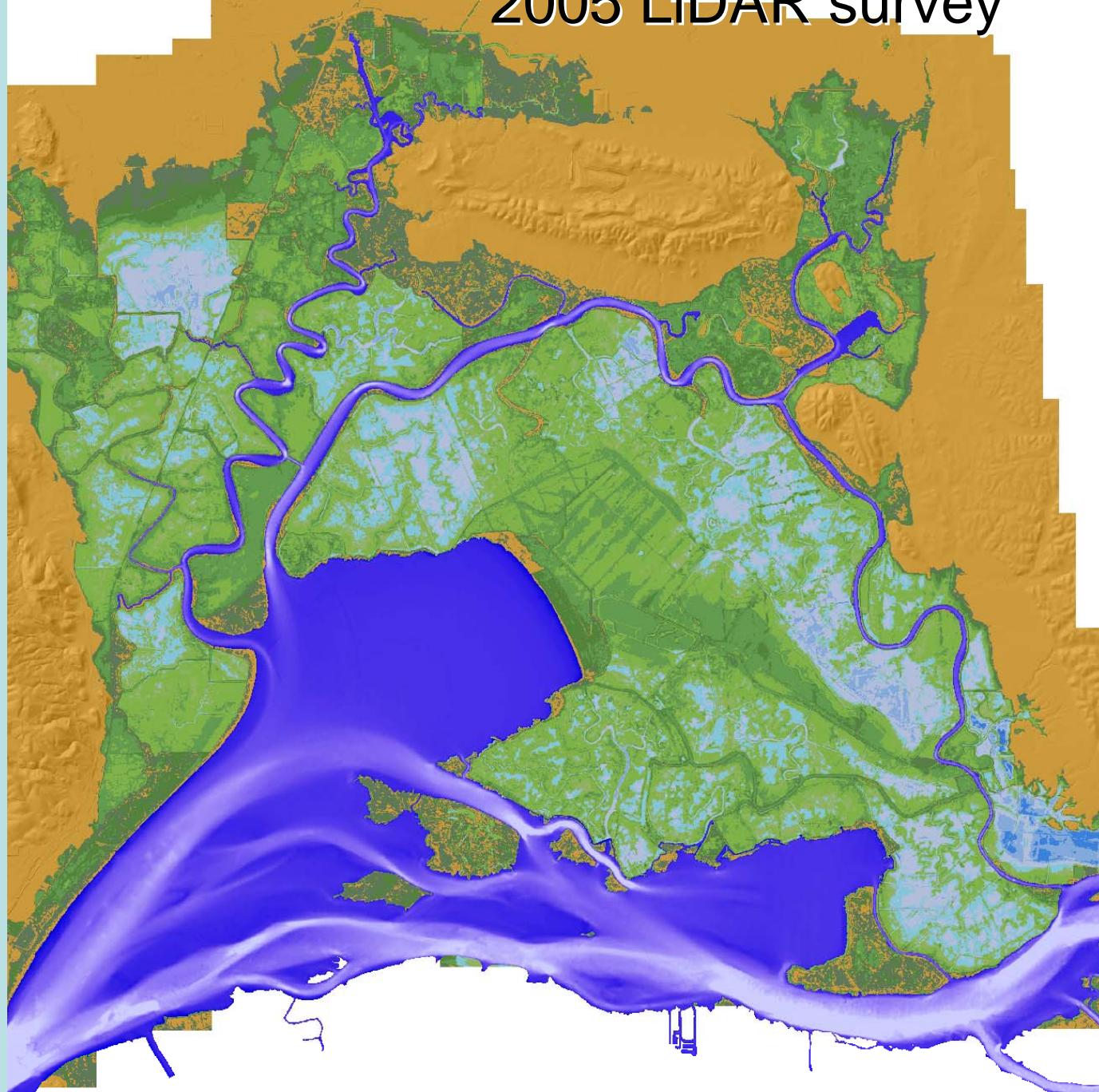


FRESH WATER

DUCK HUNTING CLUB

BRACKISH WATER SLOUGH
HIGH TIDE
APRIL 23, 2009

2005 LiDAR survey

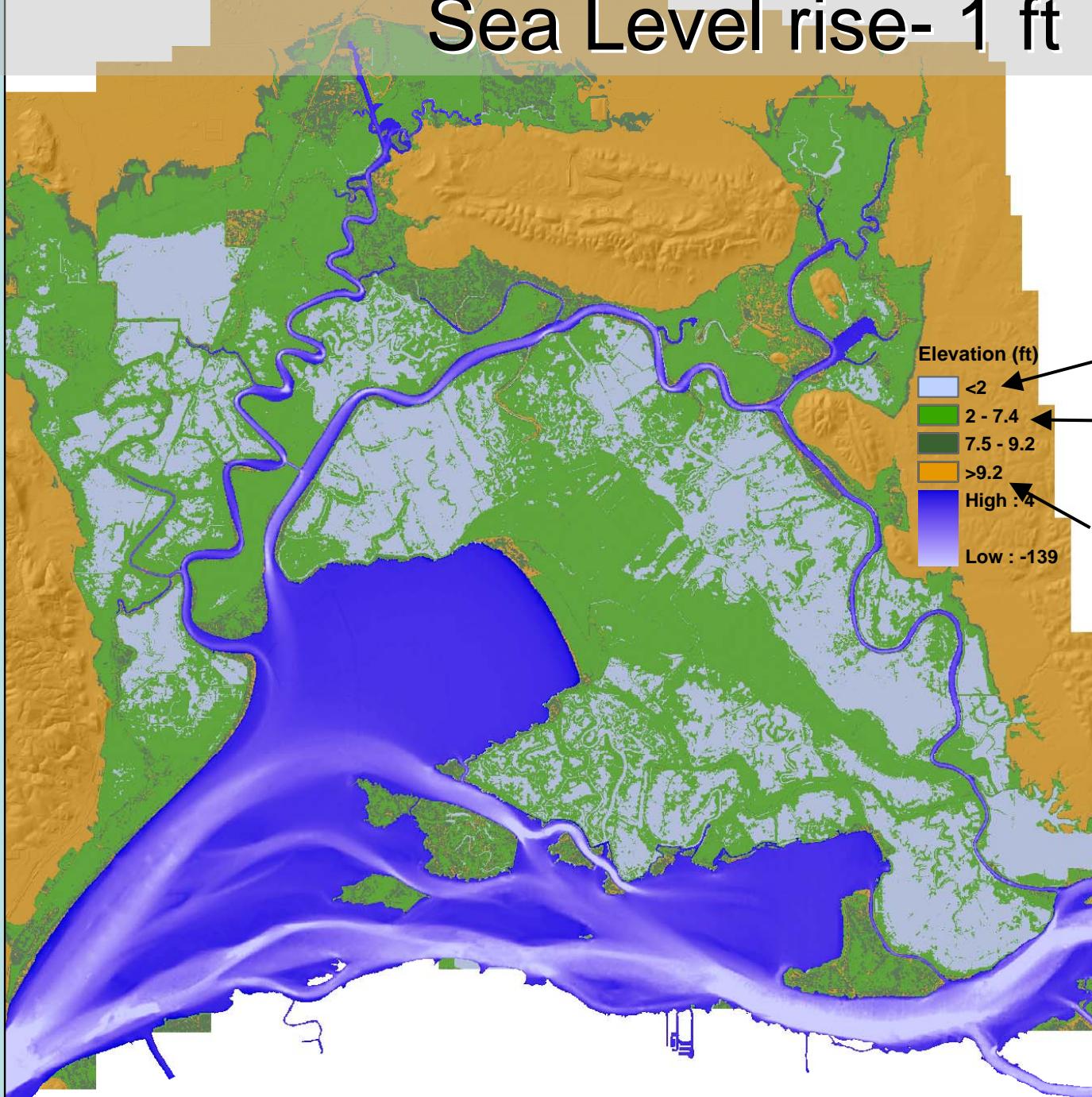


Marsh is at or below sea level (green & blue)

Mostly maintained as freshwater marsh for duck hunting

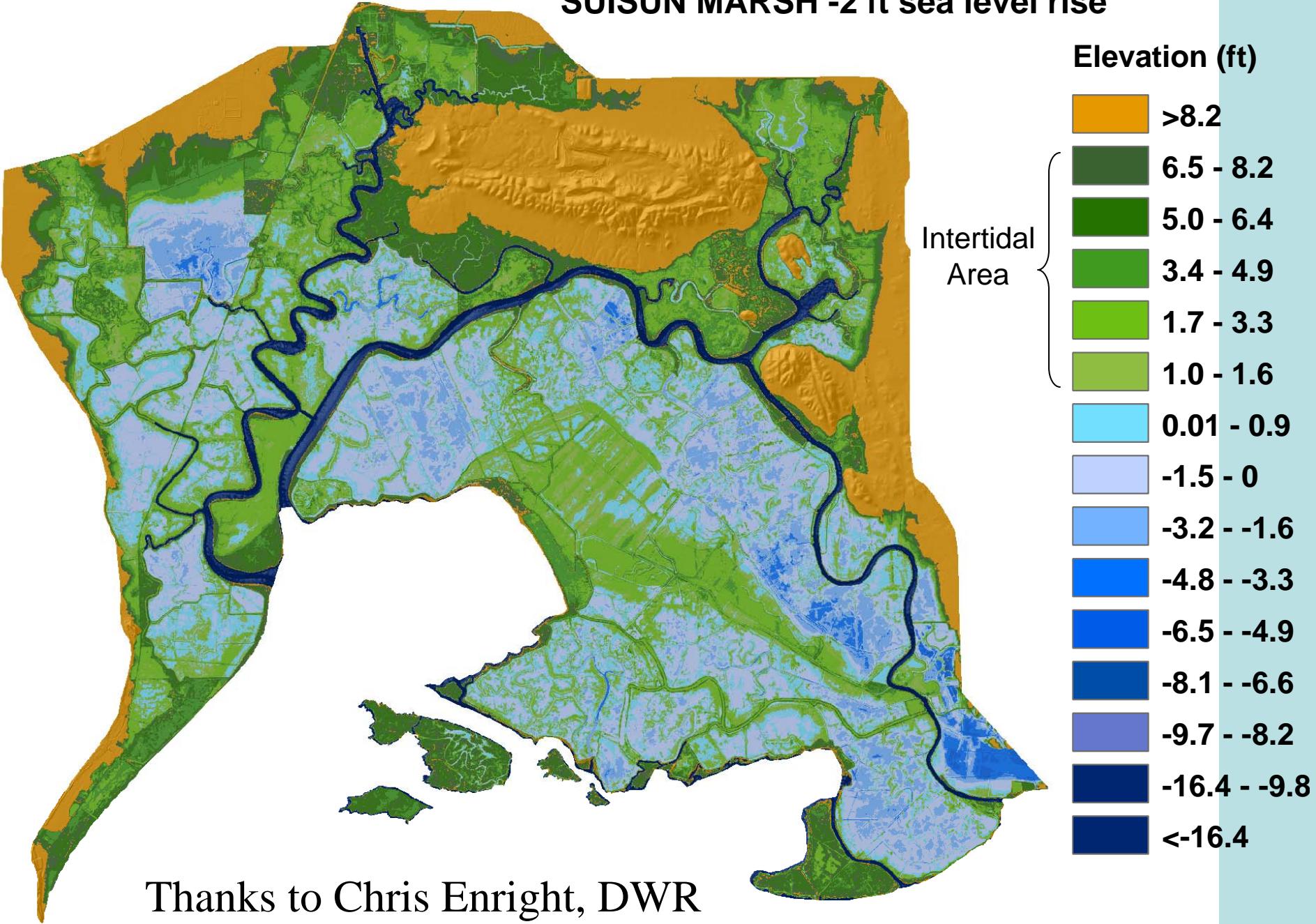
Map from Chris Enright, DWR

Sea Level rise- 1 ft



Map from Chris Enright, DWR

SUISUN MARSH -2 ft sea level rise



Thanks to Chris Enright, DWR



SUISUN MARSH 2100 (or sooner)

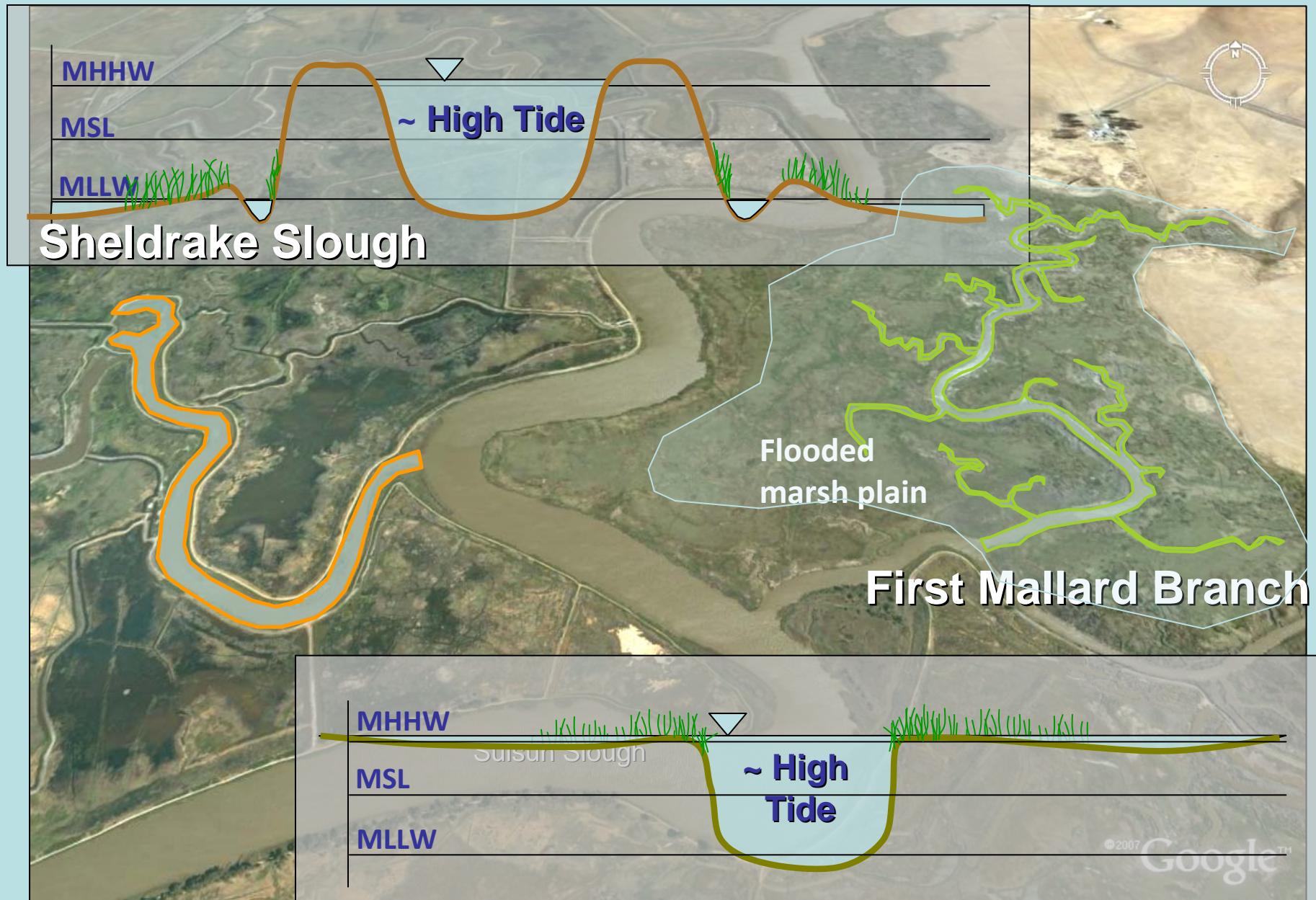
MORE TIDAL SALT MARSH

MORE VARIABLE IN SALINITY

LOTS OF SUBTIDAL HABITAT

MORE DENDRENDITIC SLOUGHS

Structure influences function



FUTURE OF SUISUN MARSH

no action scenario

- Large scale environmental change
 - More saline
 - More variable
 - More alien species
- Major regime shift in fauna likely
 - More like Napa & Petaluma Marshes?
- Productivity may decline (clams)



QUESTIONS

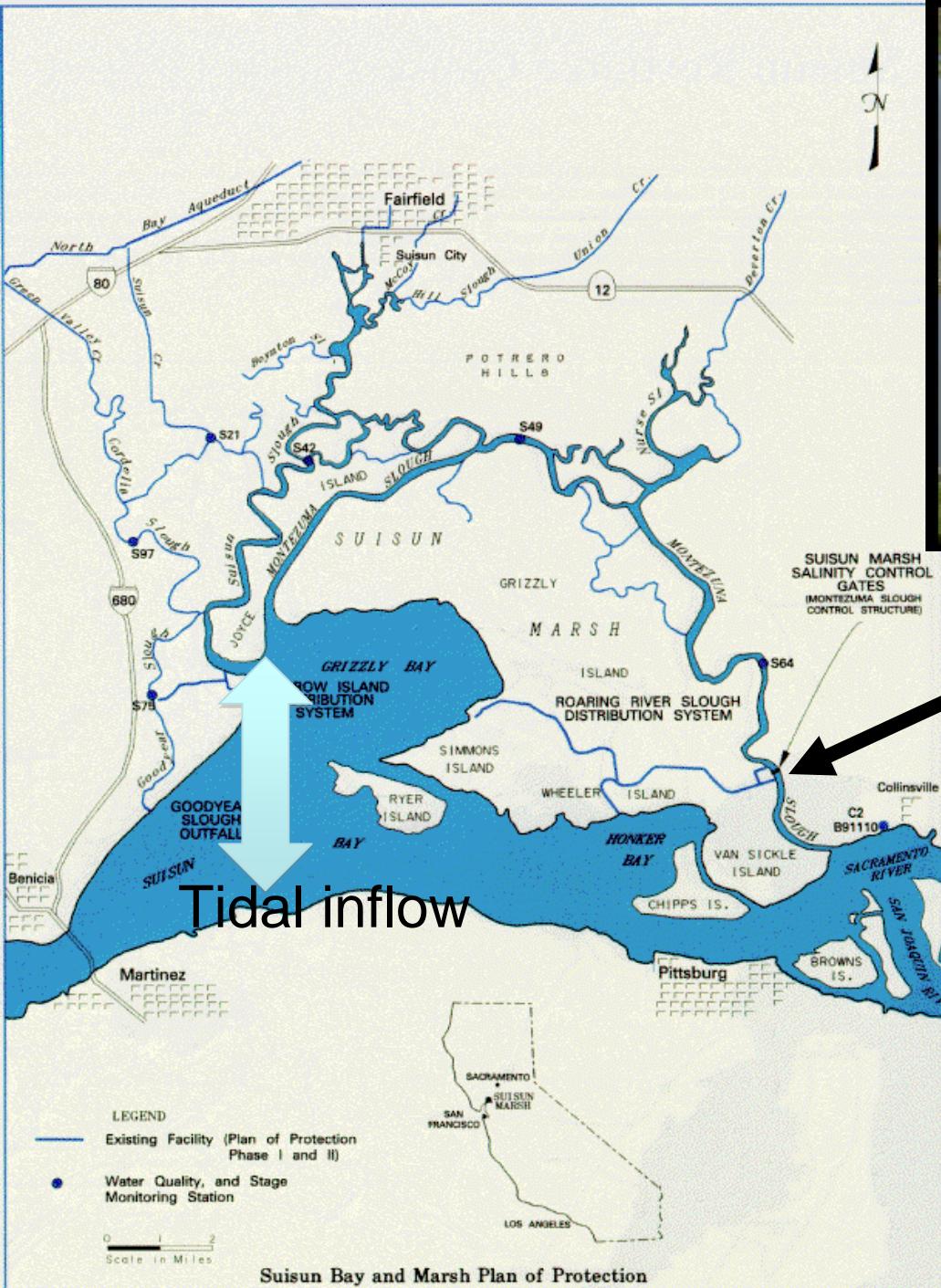
WILL PRODUCTIVITY DECLINE?

WILL THE NEW MARSH BE
WORSE FOR THREATENED
NATIVE FISHES?

WHAT WILL BE FUTURE SHIFTS
IN FISH FAUNA?

CAN WE DIRECT THE WAY
MARSH HABITAT DEVELOPS?





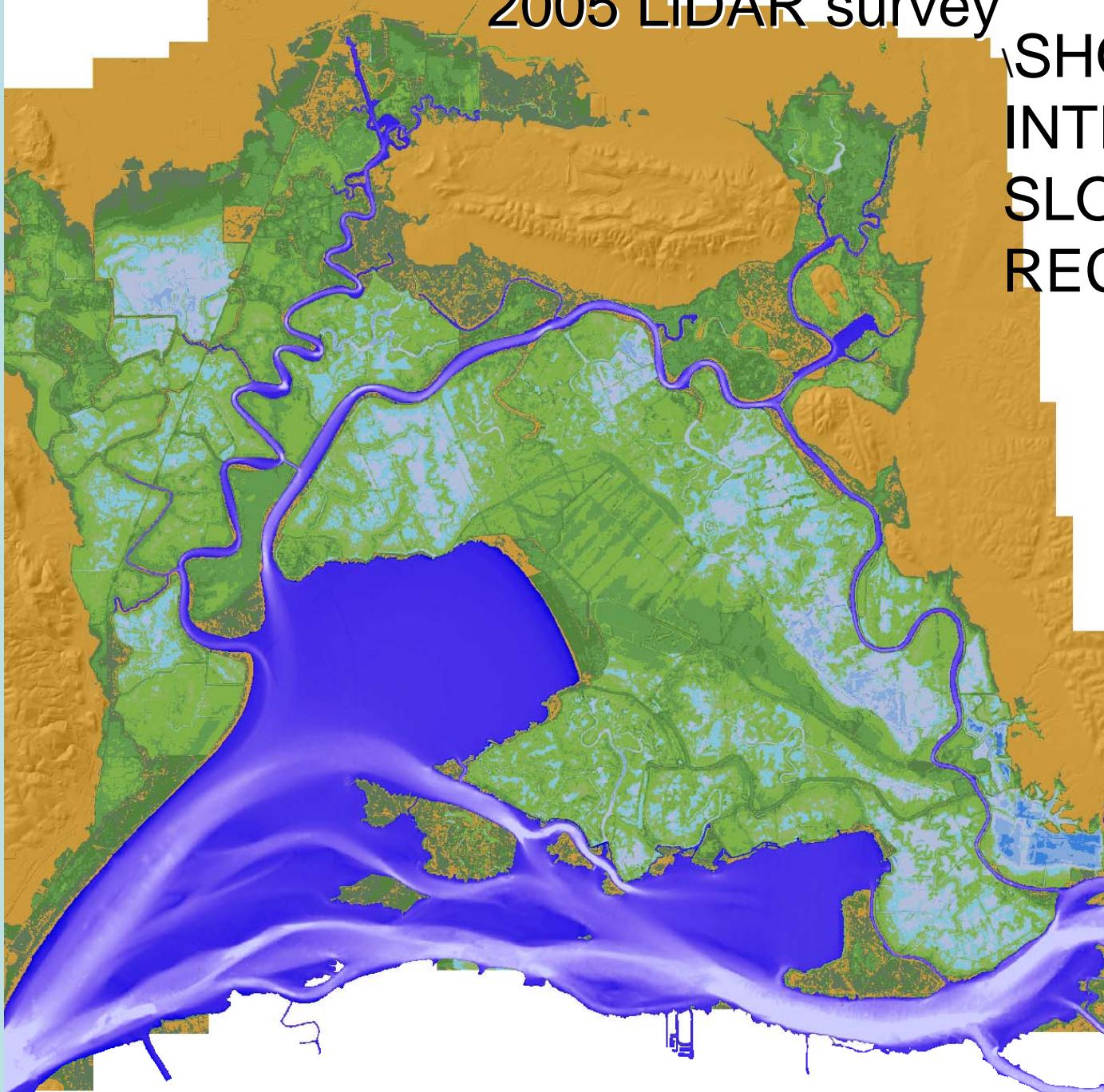
Suisun Marsh Salinity Control Gates 1989

Sacramento River inflow

HOW LONG WILL THEY FUNCTION?

2005 LiDAR survey

SHOULD
INTERIOR
SLOUGHS BE
RECONNECTED?



Map from Chris
Enright, DWR

railroad

FRESH

2005 LiDAR survey

BRACKISH

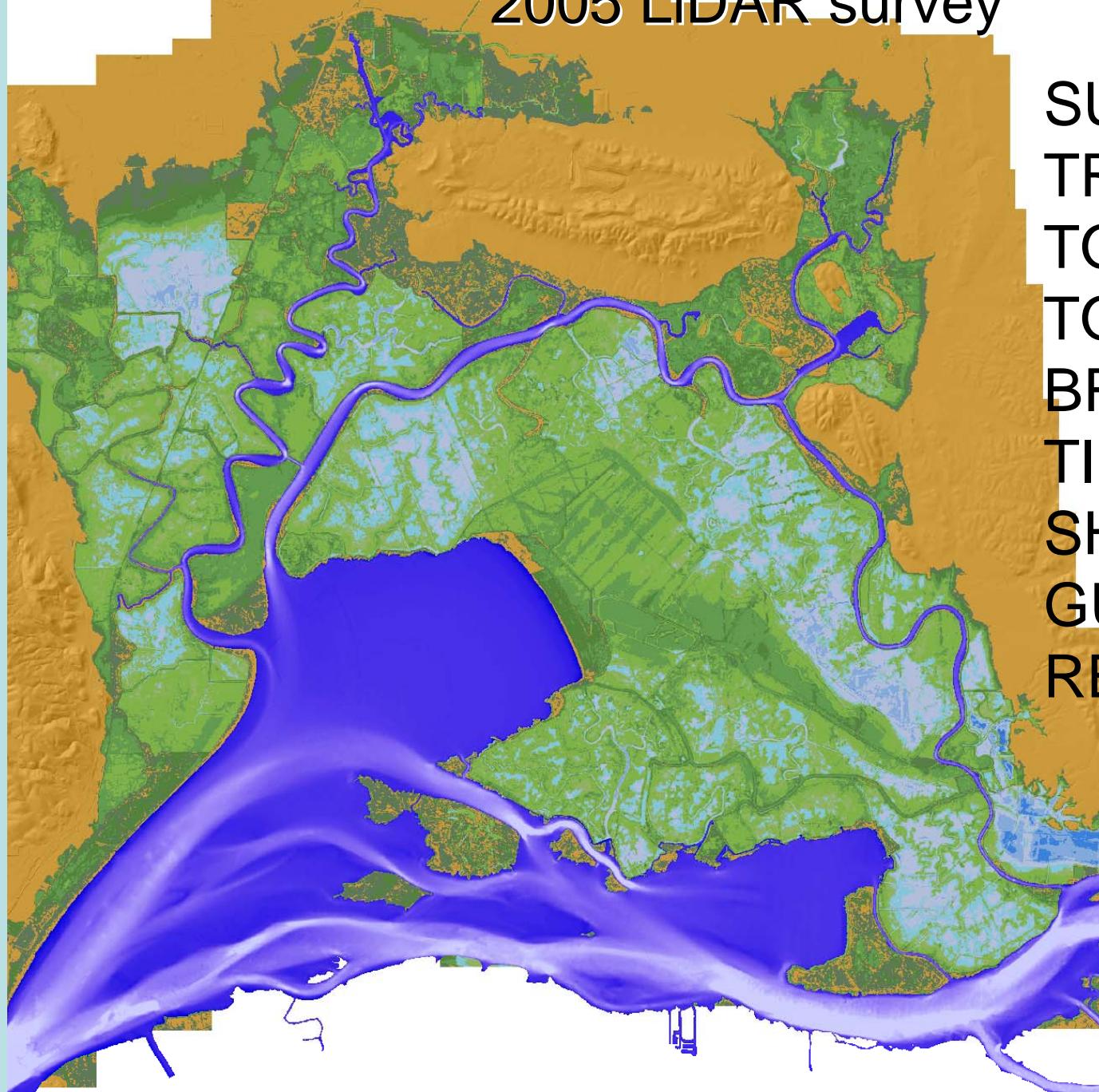
Map from Chris
Enright, DWR

Can RR
levee
be used
to divide
the
Marsh?

Marsh is at or below
sea level (green &
blue)

Mostly maintained
as freshwater marsh
for duck hunting

2005 LiDAR survey



SUISUN IS ON
TRAJECTORY
TO RETURNING
TO A
BRACKISH
TIDAL MARSH:
SHOULD WE
GUIDE THE
RETURN?

Map from Chris
Enright, DWR



ENVISIONING FUTURES FOR THE SACRAMENTO-SAN JOAQUIN DELTA

JAY LUND | ELLEN HANAK | WILLIAM FLEENOR
RICHARD HOWITT | JEFFREY MOUNT | PETER MOYLE

February 2007

Public Policy Institute of California

ENVISIONING
FUTURES FOR
SUISUN MARSH

UC DAVIS DELTA
SOLUTIONS TEAM

NOVEMBER 2010?

ENVISIONING FUTURES FOR SUISUN MARSH

- Introduction (goals)
- History
- Biota and ecosystem
- Hydrodynamics & WQ
- Drivers of change
- Economics
- Strategies for future
- Policy and management



A wide-angle photograph of a coastal town at sunset. In the foreground, there's a body of water with small ripples. On the left bank, there's a row of houses and palm trees. In the center, a marina with many boats is visible. On the right bank, there's more residential housing. In the background, there are several hills and mountains under a sky transitioning from blue to orange and yellow.

THANK YOU